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CONTENTS

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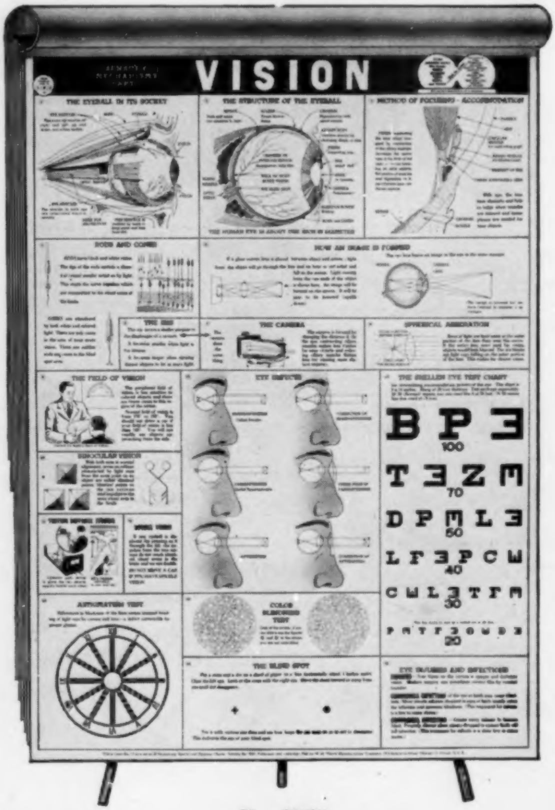

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SCIENCE EDUCATION

VOLUME 36 FEBRUARY, 1952 NUMBER 1

THE PREPARATION OF PHYSICAL SCIENCE TEACHERS IN AN AUSTRALIAN TEACHERS' COLLEGE

ROY W. STANHOPE

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A. *Introduction*

THE Sydney Teachers' College is the largest of the six teachers' colleges maintained by the New South Wales Department of Education for the preparation of teachers for the public schools, primary and secondary, of the state. Under the centralized system in operation the Education Department administers, maintains, and staffs every public school and teachers' college in the state.

Upon leaving the primary school pupils enter, at the average age of 12½ years, one of the variously named three-year junior secondary schools or one of the five-year "full" high schools. In either case the students, in each of the several available curricula, carry forward the study of seven or eight subjects continuously over a three-year period. If successful in the internal examinations covering the three years' work in each of at least four of these subjects the Intermediate Certificate [1] of the State Board of Secondary School Studies is awarded.

Persons in possession of this certificate may proceed to the fourth and then the fifth year classes in a full high school where a program of studies in five or six subjects is followed for two years. Candidates who pass the state-wide uniform examinations covering the last two years' work in each of at least four of these subjects are awarded the Leaving Certificate.[1] For entrance to a university degree course students must have passed, either at the Leaving Certificate examination or at the special Matriculation examination, in five subjects including English.[1]

In addition to the full range of courses in the separate sciences, Combined Physics and Chemistry and Biology are also available at both the Intermediate and Leaving Certificate examinations. The majority of the students in the junior classes of the public secondary schools take as their only science subject Combined Physics and Chemistry. In the two senior years Chemistry, Physics, and Combined Physics and Chemistry, in that order, are the most popular sciences amongst boys while the two highest ranking amongst the girls are Chemistry and Biology. While many boys take both Physics and Chemistry the girls, as a rule, enroll for one science only.

Apart from a relatively very small percentage of private students, the entire student body of the Sydney Teachers' College is made up of young women and young men who hold Teachers' College scholarships awarded by the State Department of Education. Candidates for these scholarships are required to

(a) hold the Leaving Certificate, including a pass in English,
(b) pass a medical examination and
(c) satisfy an interviewing committee.

[1] These statements present very generalised pictures only of the requirements governing the award of the Intermediate, Leaving, and Matriculation Certificates.

In normal times, when the supply exceeds the demand for teacher-trainees, scholarships are awarded on the basis of the aggregate marks for the six best Leaving Certificate examination papers.[2] However during the post-war years, insufficient numbers of qualified candidates have been forthcoming to fill the vacant places in the teachers' colleges. As a result the competitive provision has not operated and scholarships have been offered to all persons in possession of the minimum academic, physical, and personality standards and of teaching aptitude potential.

Each Teachers' College scholarship carries free tuition, a monetary living allowance, the loan of the prescribed textbooks for the courses being taken, a small cash grant for the purchase of other text or reference books and a refund of excess fares incurred in attendance at demonstration lessons and during practice teaching periods. In addition country students receive warrants covering free transportation over the State railways between their home towns and the College at the commencement and conclusion of each academic year.

In the first instance scholarship holders report to the particular college serving the area in which their homes are situated—the whole state being zoned for this purpose. Four of the colleges engage in the preparation of primary school teachers only; but in Sydney and Armidale Colleges courses for prospective teachers in both primary and secondary schools are available. Matriculated students entering any of the colleges, provided that they have sufficient academic standing, may be offered the opportunity to undertake university degree courses as the first stage in their preparation for teaching to the senior secondary school level.

[2] In addition to "pass" papers in five or six subjects candidates for the Leaving Certificate may present themselves for the "honours" papers in one or more of these subjects provided that the maximum number of papers be eight. Each paper, both pass and honours, carries a maximum of 100 marks.

B. *Outline of Alternative Plans at Present in Operation*

1. *For the Teaching of Science to Senior Secondary School Standard.*

   Completion of a university degree in science followed by a year at the Teachers' College in professional studies for the Diploma in Education.

2. *For the Teaching of Science to Junior Secondary School Standard.*

   (a) Two year course wholly at the Teachers' College.

   (b) One year course at the Teachers' College for students who have taken some university courses in science subjects but who have not qualified for a degree.

As will later become evident the students concerned are, also, in the majority of cases, receiving preparation for the teaching of secondary school mathematics. During the first few years in the schools, persons prepared in accordance with any one of the plans described herein, are not usually free to teach preferred subjects. In compliance with instructions from the Education Department or from the headmaster of the school to which they have been appointed, teachers early in their professional career may be called upon to teach either science or mathematics subjects or both and, infrequently, other subjects for which they have received no special preparation.

C. *Preparation for Science Teaching to Senior Secondary School Standard.*

Selection of Students for University Courses

Based upon probable future departmental requirements in the various teaching fields in the schools, university places, which vary in number from year to year, are offered to certain of the entering Teachers' College scholarship holders. This opportunity to enter upon a university degree course is made available to those students who rank highest in order of merit on the aggregate of the marks in their six best Leaving Certificate Examination papers,

provided that university matriculation requirements have been completed.

The Sciences in the Public Secondary Schools

The particular branches of science studied at the university by Teachers' College students are naturally determined largely by those science subjects which are being taught or are likely to be taught in the public secondary schools. The science enrollments in these schools are very largely in the three physical sciences namely Combined Physics and Chemistry, Physics, and Chemistry, with Biology enrollments being mainly in the relatively few separate girls' high schools. General Science is not a recognized subject in the public examinations though in quite a number of schools the first year course in the subject Combined Physics and Chemistry has been "generalised" by the inclusion of elementary treatments of a few biological and geological topics.

The Planning of University Programs in the Sciences

The American practice of extending general education, for all university students, into their first and second years is not followed in any Australian university. Instead, with general education considered to have been completed in the secondary school, Australian undergraduates enter immediately upon, and subsequently confine their attention to, courses in special areas of subject matter. Thus it happens that students proceeding to a degree in Science need not, and usually do not, take courses other than in the sciences while the great majority of those proceeding to a degree in Arts do not include any courses in the natural sciences in their studies.

With the exception that a student must complete the first year course in either Physics or Chemistry there are no required courses for the Degree of Bachelor of Science. It thus frequently happens that students graduate in science without ever having taken a single course in a biological science, either at school or at the university, while others have omitted either Chemistry or Physics from their school and university studies.

Though each student is given a considerable degree of freedom in the selection of university courses the planning must be made in consultation with the College lecturer especially designated as adviser to its university students. As has already been indicated the demand for science teachers, particularly for men, lies almost entirely in the subjects of Physics and Chemistry. For this reason Chemistry, Physics, and Mathematics have always been the basic subjects studied by most men students in the first year of the university science degree course. For many years the fourth subject chosen to complete the first year requirements was usually Geology but, in recent years, the recurring imminence of the introduction of General Science on a large scale into the schools has led the College authorities to favor the inclusion of one of the biological subjects, either Botany or Zoology, in the first year university courses of College students.

For various reasons, one being that biological subjects have always been available to pupils in the separate girls' high schools, the tendency amongst women students from the College has been, and still is, to elect those first year university courses which provide a foundation for later specialization in Botany or Zoology. These first year courses comprise Chemistry, Physics, Botany and Zoology instead of the group Chemistry, Physics, Mathematics and either Botany or Zoology selected by the majority of the men students. Some college students, both women and men, enroll each year in university Geography courses but since this subject is placed in the Commercial subjects group in the schools, the opportunities for promotion in the teaching service for science graduates with a major in Geography are meager. Geology attracts a small number of students but very few opportunities exist for the teaching of this subject in the public secondary schools.

In contrast with the American practice of organizing most courses, particularly those beyond the first year, on a quarter (term) or semester (half-year) basis, in Australian universities the academic year is the basis of course organization. For example in Sydney University there are only six courses in Chemistry, four in General and Inorganic Chemistry and two in Organic Chemistry—Pure and Applied, each of a year's duration. In Chemistry II, the second year course, there are 4 hours of lectures and 9 hours of laboratory work each week throughout the year of twenty-eight weeks exclusive of the examination period at the end of the year. The subject matter treated in lectures includes Inorganic, Physical, and Organic Chemistry—in each case at a more advanced standard than that in the first year general course. In the laboratory, one term is devoted to advanced work in each of Qualitative Analysis, Quantitative Analysis, and Organic Preparations. There are no separate courses for credit purposes in such branches of chemistry as Physical Chemistry, Qualitative Analysis, Thermodynamics, Organic Chemistry, etc. with the exception of the special one-year courses in Advanced Organic Chemistry in the third and fourth years.

In conformity with university regulations students in the Faculty of Science take three courses in the second year, two courses in the third year for the pass B.Sc. degree and one course in the fourth year for the honours degree. The particular courses taken by Teachers' College students in these years depend partly upon factuly regulations as to required sequences, combinations of subjects, pre-requisites, etc.; partly upon the student's own inclinations, and partly upon the advice of the College adviser. The latter's suggestions are influenced by the probable future requirements of the Education Department for teachers in the various subjects and also by the fact that opportunities for promotion in the teaching service depend, in no small measure, upon those courses and combinations of courses studied at the university.

As a general rule a student qualified, by virtue of his achievements in the first three courses in a particular subject, to proceed to the fourth year course leading to an honours degree in that single subject is permitted to do so and in consequence his or her Teachers' College scholarship is extended for an additional year or to cover five years of preparation in all.

The Subject Matter Preparation of the Present Methods Group

It might be of interest at this point to examine the university preparation of the students of the 1951 Chemistry and Physics Methods course in the Sydney Teachers' College. The group numbered thirty-eight consisting of four women and twenty-five men graduates in Science, five men graduates in Agricultural Science, and four men each holding a Technical College diploma which is recognized by the Education Department as being equivalent to a university degree. These diploma holders, of whom two had specialized in metallurgy, one in Physics, and the fourth in Chemistry, had studied Chemistry, Physics, and Mathematics to at least the first year university standard. A similar standard in Chemistry, Physics, Botany, Zoology, and Geology had been attained by the graduates in Agricultural Science.

The subject matter preparation of the twenty-nine students with degrees in Science are given in Table 1.

If by a "major" subject is meant one taken to the third year standard and a "minor" is one studied to the second year level then most students will have graduated with two majors and one minor. The figures in the above table reveal certain particular patterns in pre-professional or academic preparation.

(a) Of the 25 men students, 20 had majored in Mathematics, 10 in Physics, and 8 in Chemistry while minor stand-

TABLE I

MINIMUM UNIVERSITY STANDARDS ATTAINED BY MEN AND WOMEN *

	1st Yr.	2nd Yr.	3rd Yr. (Pass B.Sc.)	4th Yr. (Hons. B.Sc.)
Chemistry	22 + 4	11 + 0	8 + 0	2 + 0
Organic Chemistry (Adv.)	—	—	2 + 0	0 + 0
Physics	25 + 4	22 + 0	10 + 0	3 + 0
Botany	6 + 4	1 + 4	1 + 4	1 + 1
Zoology	9 + 4	2 + 2	1 + 2	0 + 0
Genetics	—	2 + 2	—	—
Biochemistry	—	0 + 1	0 + 1	0 + 0
Physiology	—	1 + 0	1 + 0	0 + 0
Geology	8 + 0	2 + 0	2 + 0	1 + 0
Geography	5 + 0	3 + 0	3 + 0	0 + 0
Mathematics	24 + 1	22 + 1	20 + 1	1 + 0
Statistics	—	7 + 0	—	—

* (a) The first figure in each pair refers to men and the second to women graduates.

(b) A dash (—) indicates that the course is not open to students in that particular year of their progress towards a degree.

(c) The table is to be read thus:

With regard to Physics all of the 25 men and all 4 women had reached first year standard at least, 22 of the men had reached second year standard at least, 10 of the men had completed the third year course and 3 of these men had graduated with honours.

With regard to Biochemistry one of the women students had completed Biochemistry I (a second year course) and Biochemistry II (a third year course) but had not completed the honours or fourth year course in that subpect.

ard had attained by 2 in Mathematics, 12 in Physics, and 3 in Chemistry.

(b) Amongst these 25 men students were some whose principal studies fell outside the more common Mathematics—Physics—Chemistry pattern. In this minority group were found the following majors: 3 in Geography, 2 in Geology, and one each in Botany, Zoology, and Physiology while minors were completed by 7 in Statistics and 2 in Genetics.

(c) Of the 4 women science graduates all had majored in Botany, 2 in Zoology, one in Biochemistry, and the fourth in Mathematics. Two students also held minors in Genetics while all four had completed the first level courses in Chemistry, Physics, Botany, and Zoology.

Supplementary Activities of College Undergraduates

Until some ten years ago these Teachers' College scholarship holders, once launched upon their undergraduate courses, had but little contact with the College and none at all with schools and school teaching during the three or four years spent at the university. Since then to effect a more desirable state of affairs, all undergraduates in their first year are required to take at the College an introductory course in Education while undergraduates in all years must attend Physical Education classes at the College for one hour in each week. In order that these students should have some first hand experinces with schools and schooling before beginning the professional year at the College, each is required to devote, early in the second and third years and prior to the commencement of the university academic year, a period of two weeks to observation and teaching in a primary school. This period is spent in a school of their own selection, usually in close proximity to the student's home, and is not under the supervision of the College staff.

Up to this present year science undergraduates in their second year were required to attend a course, especially arranged for their benefit, in the History of Science for one hour a week during the first two of the three terms which constitute the academic year. The growing realization that such students possessed insufficient knowledge of the factual content of the sciences to appreciate fully the subject matter, the pressure of university studies, and the increasing difficulty in finding an hour in the week at which all would be able to attend the College for this course, have been responsible for the decision to abandon this requirement. Commencing in 1952 a course in the History of Science for one hour weekly throughout the year will be

required of all science graduates enrolled in the professional year of studies leading to the university Diploma in Education.

To assist Teachers' College students in each of their first and second year university courses, one-hour tutorials are conducted each week by members of the College staff. Through this arrangement another opportunity is made for fostering closer links between the College and its staff, and its university students.

The Final and Professional Year of Preparation

During the year following graduation with either a pass or honours B.Sc. the prospective science teacher is engaged in full-time professional studies and activities leading to the university Diploma in Education. In addition to lecture courses, observations and practical teaching experience prescribed in the programs for this post-graduate diploma, certain other courses are required by holders of Teachers' College scholarships. By arrangement between the Sydney University and the Teachers' College authorities the lecture courses for the Diploma in Education, in addition to those required of Teachers' College scholars, are given in the College lecture rooms by members of the College staff. Arrangements for and supervision of practice teaching are also largely the responsibility of the College.

Completion of the total program of the professional year satisfies the academic requirements for the Teachers' Certificate of the State Department of Education. The certificate itself is not awarded until after the completion of one year of satisfactory teaching experience in the public schools of the state.

The Schedule of Courses [3]

In view of the fact that some alteration in the program of work for the professional year is under consideration for 1952 it may be of interest to contrast the schedule of courses for 1951 with that proposed for 1952—as far as they concern science graduates.

TABLE 2

SCHEDULES OF COURSES FOR THE PROFESSIONAL YEAR

Operated in 1951		Proposed for 1952	
1. Education	3 hours	Education	3 hours
2. General Method	1 hour	General Method	1 hour
3. Special Methods (in 3 subjects)	6 hours	Special Methods (in 2 subjects)	4 hours
4. History of Education	1 hour	History of Education	1 hour
5. Educational Psychology	1 hour	Educational Psychology	1 hour
6. Hygiene	2 hours	Hygiene	1 hour
7. Physical Education	1 hour	Physical Education	2 hours
8. Speech Training	1 hour	Speech Training	1 hour
9. General Psychology	2 hours		
10. Optional Subject	2 hours	Optional Subject	2 hours
11. General Biology	2 hours	General Biology	2 hours
		History of Science	1 hour
		English	1 hour
		Ethics	1 hour
12. Demonstration Lessons	2 hours	Demonstration Lessons	2 hours
Totals	22 or 24 hours		21 or 23 hours

[3] The academic year for these post-graduate students in the Sydney Teachers' College comprises three terms of overall length 11, 10 and 15 weeks respectively. Of these 36 weeks, 24 are given over to regular course work, 7 to practice teaching by students, 3 to the preparation for and the sitting for final examinations, and one week to visits to special educational and social service institutions in the metropolitan area. The lecture courses are, like those of the university, organised on an annual, not a term basis i.e. each course runs right through the whole academic year.

In 1951 candidates for the Diploma in Education were required to take Courses 1 to 6 while students holding a Teachers' College scholarship had to take, in addition, Courses 7 and 8 and also 9 unless they had completed the first year course in Psychology.

Science graduates who did not include a biological subject in their university programs were required to take Course 11 while the others were required to select one of the available "options." The College time-table was arranged so that those students required to take Course 11 could also take one of the optional courses if they so desired. During 1951 the list of options included Music, Art, Handicrafts, Religious Education, Geography (open to students who had either not studied this subject before or who had not progressed beyond the first year course at the university), and English Literature.

The principal points of difference between the present and proposed programs would seem to lie in the following:

(a) the number of required Special Methods has been reduced from three to two although, under the new plan, students will be advised to take a third method course where the time table permits and

(b) courses in History of Science, English Literature, and Ethics are being added while General Psychology is to be dropped. This seems a rather surprising omission in view of the fact that only rarely indeed is Psychology included in the undergraduate program of students proceeding to a science degree in the Sydney University. Unless some late change is made future Science teachers in this state will be deprived of the opportunity during their student days of acquiring in a formal course that knowledge of general and adolescent psychology which, most people would assert, underlies the courses in Educational Psychology and Special Methods, and the teaching in the schools. However it is intended that students, deficient in a knowledge of the subject, should read for themselves, either during the preceding long vacation or during the early part of the academic year, a general text in Psychology.

Observation of Demonstration Lessons

It is not anticipated that the activities embraced under the designation "Block Demonstrations" will be significantly altered in the coming year. During the past year the weekly time allotment of two hours was given over in rotation to demonstrations in Combined Physics and Chemistry, Biology, and Mathematics so that once in every three weeks the Physics and Chemistry Method students witnessed demonstration lessons in an Intermediate High School within five minutes walking distance of the College. Usually the group was able to observe, with different classes, one double-period of laboratory work and one single period "theory" lesson during each visit to to the school. It was usually possible to proceed with a discussion of the lessons during the following lecture-hour which happened to be that time-tabled for one of the physical science method courses. By arrangement with the demonstration school science staff it was made possible for the students to observe the various kinds of lesson procedures being used in both Physics and Chemistry over a wide range of classes.

The Science Teaching Method Lecture Courses

Students in attendance at the Teachers' College for the professional year of preparation following upon the completion of a university first degree were, up to and including the year 1951, required to select, in order of their personal preference, three Special Method courses each meeting for two hours weekly. The particular method courses chosen were obviously those for which the student had received academic preparation during the university under-

graduate years. Beginning in 1952 only two of these teaching method courses will be required of each student but attendance at a third such course will be advised.

Omitting the five Agricultural Science graduates, who invariably chose Agriculture, Biology, and Combined Physics and Chemistry as their three Special Method courses in that order of preference, the preferred teaching subjects of the remaining thirty-three members of the 1951 physical science method courses were as given in Table 3.

TABLE 3

TEACHING METHOD ELECTIONS BY SCIENCE METHODS STUDENTS

Subject	1st Preference	2nd Preference	3rd Preference	Total
Chemistry	8	11	12	31
Physics	3	20	8	31
Combined Physics and Chemistry	0	0	2	2
Biology	3	1	2	6
Geography	0	1	0	1
Mathematics	19	0	9	28
Totals	33	33	33	99

In the years prior to 1949 the special method courses in Physics and Chemistry were entirely independent of one another and were handled by two different lecturers, one belonging to the Physics Department of the College and the other to Chemistry Department. It became evident that much repetition and overlapping of lecture materials was unavoidable so long as the teaching method courses in these two subjects remained independent of each other and, at the same time, each enrolled substantially the same students. Some kind of amalgamation or close integration was also obviously necessary since the greatest demand in the public secondary schools is not for teachers of Chemistry nor for teachers of Physics but for persons qualified and able to teach both of these sciences. The majority of science teachers serving the schools of the state are concerned, for most of their teaching time, with classes in the single subject Combined Physics and Chemistry, this being a required subject of all boys and of many girls in the three grades of the public junior secondary schools. Physics and Chemistry as separate subjects are found only in the two senior grades of the public high schools. Another factor of importance in stimulating the fusion of the two formerly separate methods courses arises from the extension within recent years of the Combined Physics and Chemistry course into the upper secondary school levels. This course now has the same official academic standing in the Leaving Certificate Examination as has been given always to Chemistry and Physics as separate subjects.

It is the opinion of the lecturers in the two College departments concerned that the present arrangements of the Special Methods courses for the preparation of teachers in these two special fields of science represent a marked and very desirable improvement over those previously existing in the College. In brief, the present plan provides four separate but closely related lecture courses, each meeting for one hour in each week. Students taking one method in this field participate in the activities of the first two of these courses and are thus prepared for the teaching of Combined Physics and Chemistry with junior secondary school classes. Those students who desire preparation for the teaching of this combined subject and also for the teaching of Physics and Chemistry as separate subjects in senior high school classes must attend all four courses which count as two Special Methods courses.

The Methods Courses in Some Detail

In Course I consideration is given to those general principles which are considered to underlie the informed teaching of Physics and Chemistry at any level of secondary schooling. Treatment is given of such topics as the history and aims of science teaching; the school science offer-

ings in the English speaking countries; the selection and organization of course content; the evaluation of the outcomes of science education; methods for the enrichment of science teaching; the place, purpose and use of instructional materials; the science teacher in the community and the literature of science education.

In Course 2 are treated the more important problems associated with the teaching of Combined Physics and Chemistry with the junior secondary school classes. The general principles of science teaching discussed in Course 1 are applied to such problems as

(a) the selection and organization of course content,
(b) the selection and use of textbooks and other instructional aids,
(c) the demonstration of experiments,
(d) the laboratory experiences of pupils and
(e) suggested treatments in detail of selected topics.

From time to time a group of two or three students, under the guidance of the lecturer, prepares and presents to the remainder of the method class a suggested treatment of a particular topic illustrated by lecture-demonstration experiments.

In Courses 3 and 4 special problems associated with the teaching of Physics and Chemistry respectively at the senior high school level are treated much along the lines of the plan described above for Course 2. In addition some attention is given to the periodical literature available to pupils, to the professional journals for science teachers, and to research investigations in the teaching of Chemistry and Physics.

Class assignments in connection with these courses during 1951 have included the following:

(a) a critical examination of the aims of science teaching as expressed by British, American, and Australian writers,
(b) the nature, place and value of objective questions as contrasted with essay or problem type questions,
(c) examination and critical evaluation of British, American, and Australian textbooks, laboratory manuals, and workbooks.
(d) the relative values to the science teacher of the various professional journals.

Individuals and small groups of students have completed assignments on a wide variety of topics including:
(a) the preparation and presentation to the College group of suggested methods for the treatment of certain topics in the school physical science courses,
(b) the building up of a departmental file of cards containing descriptions of experiments, demonstrations, techniques and procedures of value to science teachers obtained from professional journals, textbooks and other sources,
(c) the compilation of lists of suitable films available for exhibition to science classes,
(d) an account of the services rendered to schools and teachers by Australian museums,
(e) a survey of science broadcast sessions for adult listeners,
(f) the policy of the metropolitan daily newspapers with regard to the frequency and nature of articles on scientific topics, and
(g) assistance in the collection and analyses of responses to enquiries into current practices in certain aspects of science teaching in secondary schools.

Practice Teaching Experiences

Students, as a body, move into the schools for two periods of continuous teaching practice during the professional year of their preparation. The first period of three weeks' duration has customarily occurred in the middle of the first term but beginning in 1952 it will take place during the second term. This later placement better suits the schools since the overall

period available for straight-forward teaching in the first term is already, without the dislocation necessarily associated with practice teaching, considerably reduced due to the time involved in the settling-in process at the beginning of the year, to the time lost during the closure of schools for the Easter recess and for a public holiday (Anzac Day) and to the teaching time lost in those many schools in which mid-year examinations are held towards the end of the first term.

Another, and to the College and its students, perhaps the most important reason for the advisability of deferring the practice teaching period to the second term arises from the fact that whereas under the former arrangement students began practice teaching after only four and a half weeks in College they will, in future, have completed more than a full term of course work and will have attended a much larger number of demonstration lessons.

To suit the convenience of the College and of the schools concerned, the second practice teaching period will continue to occur during the last month of the College and school year. Final school examinations, the absence of the third and fifth year public examination candidates, the depleted classes in the other years in many schools and the-end-of-the-year-and-examinations-over feeling amongst most of the pupils still in attendance combine to render this second practice period of considerably lessened value to the teacher-trainee. On the other hand it is hardly to be expected that the schools will be willing to have the routine of the better teaching periods of the year disturbed by the presence of practising Teachers' College students.

During the periods in the schools students are required to teach fourteen periods each week (three periods per day and two during the morning of the day on which the weekly sports afternoon falls) and to observe ten periods per week (two per day.) While the student is expected to have the opportunity to gain teaching experience in each of his three chosen Special Methods subjects, the fourteen teaching periods are to be distributed amongst these subjects in decreasing order of their preference as Special Methods. A suitable distribution might well be seven periods in the subject of first choice, five periods in that of second choice and two periods in the third subject.

Competent supervision and criticism of each student's lessons in the subjects of his first and second preference are given by the College lecturer in charge of each group of about ten or twelve students distributed amongst three or four schools. However, because of staffing difficulties, the College cannot always provide supervisors qualified to comment critically upon lessons in third method subjects.

Adequate notes, which must not be written up during school hours, are to be prepared for all lessons which the student is to give. No inadequately prepared lessons may be given without the special permission of the supervisor. As soon as possible after each lesson has been given, the student is required to write his comments upon it. These comments, of a critical character, are for the purpose of affording guidance to the student on the next occasion on which a similar lesson has to be given.

In addition to a Lesson Notebook, each student is required to keep an Observation Book in which is to be recorded accounts of experiences and observations likely to be of use during his teaching career. Details of the school's routine and organization, of novel methods of teaching, of the availability and use of teaching aids and free materials, and the use of standardized tests are but a few of the many aspects of school life listed in the College calendar as being worthy of inclusion in the student's observation book.

At the close of each practice teaching period the supervisor writes a report upon the personality, attitude, and work of each student in his charge. Each student has the right to be informed of the contents of

his own report upon application to the Staff Adviser of his section. In addition to this written report, each student after the second practice is awarded a Teaching Skill Mark by his supervisor. These marks range from C— to A+, where C— indicates unsatisfactory teaching aptitude and A+ represents a high order of skill not generally found in more than one per cent of students. Before the recommended award of A+ or C— is confirmed the student is visited, while engaged in classroom teaching, by one of the senior lecturers of the College who then confers with the supervisor who has been in regular contact with the particular student. Generally speaking the award of C— Teaching Mark is accompanied automatically by a recommendation to the Education Department that the student's scholarship should be withdrawn or that, in the case of students whose College course has been completed, the student reach an acceptable standard of teaching ability in an additional period of practice teaching before being appointed to the staff of a school. The B— mark is the lowest award satisfying the practical teaching standards for the University Diploma in Education.

D. *The Two-Year College Plan of Preparation.*

Entry into the Course

A two-year course, conducted wholly within the College, provides another avenue for the preparation of science teachers but for teaching to the junior secondary level only. This course, officially entitled the Junior Secondary Science Course, is available to those students who either fail to gain selection for or do not care to enter upon, the four or five year course already described. Students recruited into this section are required to possess substantial Leaving Certificate qualifications in Chemistry, Physics, and Mathematics. The maximum permissible enrollment of 24 students is not always reached, either because of a dearth of suitably qualified candidates or because some qualified students prefer to take up some other field of teaching. In view of the fact that opportunities for the teaching of the physical sciences in girls' junior secondary schools are very limited indeed, it is not usual to find women students in the section. In 1951 there was an enrollment of 18 men and 1 woman in the course.

The Program of Studies

It is well appreciated by the College and other authorities that no two-year course can provide adequately for the extension of the general education of its students and for their preparation for the teaching of science and mathematics in schools. It seems highly probable that when the present grave shortage of teachers has been overcome the period of preparation will be extended to three years. In the meantime plans already in existence for such a lengthened course are being held in abeyance.

In the past, the program of studies and demonstration lessons for this section has been very heavy, amounting to 25 hours in the first year and 23 hours in the second year. Beginning in 1952 the first year students will be allowed more free time for library work and for those very desirable contacts with members of their own and other College sections in the common room and the quadrangle by the omission of the 3-hour "option" and by the reduction by one hour of the time previously given to Chemistry. Despite this overall reduction in required hours it is recognized that the weekly load is still too great even after admitting the fact that six of the hours are spent in the science laboratories. It is rather difficult, however, to remedy this defect and still provide adequate preparation for teaching in a course of only two years' duration.

The present and proposed programs are set out in Table 4.

In the first place it will be noticed that, beginning in 1952, the program of studies

TABLE 4

SCHEDULE OF LECTURES FOR THE JUNIOR SECONDARY SCIENCE COURSE

(hours per week throughout the year)

	First Year		Second Year	
Subject	1951	1952	1951	1952
English	3	3	2	2
Education	4	4	4	4
Social Science	–	–	2	2
Physical Education	–	1	1	–
School Hygiene	–	–	1	1
Mathematics	3	2	3	3
Biology	3	3	–	3
Physics	4	4	4	4
Chemistry	5	4	5	4
Option	3	–	–	–
Science Method	–	–	1	–
Totals	25	21	23	23

will consist entirely of required courses. The optional course, which the student could elect in 1951 from a wide variety of available subjects of a general and cultural nature, is to be dropped to bring about a reduction in the total lecture load. In contrast with the specialized academic and professional courses of the combined university degree and diploma program of preparation for teaching to the senior secondary school level some provision is made in this two-year course for the extension of the general education of students. Two-hour courses in English Literature in each of the first and second years and a two-hour course in Social Studies entitled "The Contemporary World" constitute this provision for general education. The third hour set down under first year English is devoted to remedial work in oral and written expression.

If the State Education Department's plans to introduce General Science into its secondary schools be soon implemented, there will be an immediate need for teachers qualified to treat both biological and physical science aspects of such a course. To meet this need, the time given to the study of Biology will in future be twice that previously available. From 1952 this subject will receive three hours weekly in both years instead of the three hour course in the first year only for the sections entering in 1951 and in previous years. With six year-hours of course work Biology will, in future, be ranked with Mathematics, Physics, and Chemistry as major content subjects. To accommodate the new three-hour Biology course in the second year, Physical Education is to be transferred to the first year, the Chemistry hours are to be reduced from five to four while the separate one-hour course entitled Science Method is to be dropped. In the new program the time allotted in the second year for Chemistry, Physics, Biology, and Mathematics must suffice for both content studies and special method work in these subjects. Demonstration lessons, for which two hours each week will be available, will rotate one week in three between Combined Physics and Chemistry, Biology, and Mathematics. in keeping with the practice already described for students in the post-graduate course. For Biology demonstrations, students must travel to schools at some considerable distance from the College but lessons in the other subjects are provided in a junior secondary school quite close to the College.

The Courses in the Sciences and Mathematics

While the College provides for the students, following this two-year program, substantial courses at the tertiary level in the basic sciences and mathematics it is the intention that these courses should not be mere imitations of the traditional university offerings in these subjects. Rather is it the desire of the College to provide subject matter courses which will serve as better foundations, for both modern living and for teaching in special fields, than the university courses bearing identical titles. As would be expected, there is in some portions of the science and mathematics courses in both institutions a close similarity in content—particularly is this true in respect to Physics and Mathematics. In the College Chemistry courses approxi-

mately one half of the time is spent on lecture and laboratory topics that are found in the usual introductory courses at the first year university level. Courses in Botany and in Zoology, but not in Biology, are available in the University of Sydney so that it is not possible to make general comparisons between the College Biology courses and any one of the university offerings.

In very general terms the ground covered during the two years of College work in the sciences and mathematics approximates to that covered in the first year university courses in these subjects. There are several reasons for this apparently slow rate of progress. In the first place the College lecture year is some three or four weeks shorter than the university year, secondly, a lesser number of hours is available each week for lectures and laboratory work in any particular course, and finally the College student has to cope with a greater number of courses at any given time than his university counterpart.

There is a fairly close correspondence both in scope and in depth of treatment between the two-year College courses in Physics and in Mathematics and the first year university courses in these subjects. Thus in the College Physics courses attention is given to the customary topics in the following branches: Properties of Matter, Mechanics, Heat, Light, Sound, Magnetism, and Electricity.

It is in Chemistry that the greatest difference is found between the College courses and the general introductory course in a university. In the secondary school each of the College students in this group will have completed the three-year Combined Chemistry and Physics course in the junior secondary school and the subsequent two-year Chemistry course for the Leaving Certificate examination. In school he will, in these courses, have covered much of the subject matter, particularly in inorganic chemistry, of the usual first year course in a tertiary institution and will also, in the laboratory, have had first-hand experience of inorganic preparations, of the reactions underlying qualitative analysis, and of quantitative analysis, both volumetric and gravimetric. With students so well grounded in basic chemical knowledge and in laboratory techniques, the College chemistry staff is able to offer courses containing some unusual and particularly valuable elements.

The first year lecture course includes, in addition to a review of some of the secondary school topics from the viewpoints of the periodic classification and of the electrochemical series, detailed consideration of the development of the quantitative laws of chemical combination and of the modern theories of the structure of matter and of valence. In the treatment, particular attention is given to examples of the applications of scientific methods to the solution of research problems. Consideration of certain topics in physical chemistry such as the properties of dilute solutions, chemical equilibria, dispersions, and thermochemistry complete the first year lecture course. During the first half of the year, the laboratory course is devoted to experiments which exemplify certain fundamental topics in general chemistry such as Gay Lussac's Law of Combining Volumes, the determination of the molecular weight of a volatile liquid employing a simplified form of Dumas' apparatus, the prediction (from periodic table considerations) and subsequent vertifications (?) of the properties of selenium and the Law of Mass Action. In the latter part of the year a course in systematic qualitative analysis is followed.

One term in the second year Chemistry course is given over to a general survey, through lectures and associated laboratory work, of organic chemistry thus revising and extending the secondary school treatment of this branch of chemistry. During another term an outline of the history of chemistry is given, partly through lectures and partly through papers prepared and delivered by the students themselves. In the last term, some of the lecture hours are

spent in a treatment of the scientific principles involved in the more important chemical and mining industries. During portion of the time available each student delivers a resumé of the comprehensive report which he has prepared on an important Australian chemical or mining industry. In the laboratory during this third term, the students work individually upon the planning and reproduction, on a laboratory scale, of experiments designed to demonstrate some of the more important processes in applied chemistry.

Half-day excursions are made, during the year, to the Minerals and Mining Museum, to the Museum of Applied Science, and to industries and public utilities in the metropolitan area. An extended visit, of several days' duration, is usually made to an important industrial center, about 100 miles distant, where inspection is made of the processes of manufacture of iron, steels, cement, superphosphate, the mineral acids, and of the electrolytic process for the refining of copper.

Other Experiences in the Two-Year Course

In the first year of the course, the demonstration lessons and the two practice teaching periods are concerned with the teaching of the basic subjects namely English, Mathematics, and Social Studies at the higher elementary school level. In preparation for this classroom work, the methods of teaching these subjects are given consideration in the lecture courses in Education, English, and Mathematics.

The school classroom experiences during the second year are directed, for the most part, to the teaching of mathematics and science in junior secondary schools. The arrangements for and the nature of the demonstration lessons and the practice teaching periods are substantially the same as those already described for the group of students undergoing preparation for the teaching of science and mathematics to the senior high school standard. Similarly the course in the teaching of the physical sciences is almost a replica, though in somewhat condensed form, of Courses I and II as given to the post-graduate students (previously described above).

E. *The One-Year Course for Ex-University Students.*

The Composition of the Student Group

As has been already mentioned teachers for the public schools in New South Wales are, in the very great majority of cases, those persons who have completed courses of preparation while holding scholarships awarded by the State Department of Education. It invariably happens that a number of these teacher-trainees, to whom university free places had been granted, fail to qualify for progression from one year to the next of their university degree courses. Generally speaking these students are permitted, if they choose, to repeat their failing university courses at their own expense. If this offer is accepted the student concerned receives no monetary allowance during the year and must also pay his or her own university fees. If the offer is declined, the student is required to return to the College for one year and to enter one of the so-called "Ex-University" sections. Until recently the only College course then open to such students was that leading to general classroom teaching in public elementary schools. In the last few years, however, in an endeavor to meet a demand for science and mathematics teachers in junior secondary schools, those ex-University students who have completed portion of a science degree program have been given the opportunity of undergoing preparation for teaching in these fields.

In this section are also placed those persons who, after failing to complete satisfactorily, as private students, university degree programs in science, engineering, dentistry, medicine or veterinary science, have been awarded Teachers' College scholarships tenable for one year. These persons, during their first year studies in the various faculties at the University, will have

at least completed, though not always satisfactorily, courses in four or more of the subjects Chemistry, Physics, Botany, Zoology, Geology, and Mathematics. In the eyes of the College and Education Department authorities these students possess academic qualifications of value for the teaching of science and mathematics.

This section then comprises two kinds of students each of whom has been exposed, for at least one but more often for two or more years, to university courses in the sciences and mathematics. Some in the group have held Teachers' College scholarships while attempting university courses, whereas the remainder are new recruits. While it is true that these latter students have turned to teaching as the next best profession offering to that in which their primary interests lay and for which they had attempted university preparation the great majority of them have shown a degree of maturity, interest, and enthusiasm that augurs well for their success in the schools.

The Program of Studies and Other Activities

The program of courses and other activities for this section was, in many respects, identical with that for the second year of the two-year College group whose teaching subjects, junior secondary school science and mathematics, will be the same. The lecture schedule is shown in Table 5, which also shows, for ready comparison and contrast, the schedule for the second year of the two-year College course.

It will be noticed that the ex-University group was allotted two hours less for Chemistry and two hours less for Physics than the purely College section. This reduction operated because the former group had covered, in their university courses, a much wider range of topics in these subjects than the latter group in their first College year and because hours for other subjects were required for the returned university students. The four hours so gained were distributed thus: two hours to General and Educational Psychology and two hours to Biology. Through this rearrangement it was hoped to effect the closest possible similarity in the total tertiary studies of the two groups.

TABLE 5

SCHEDULE OF COURSES FOR SECOND YEAR STUDENTS IN 1951

Course	Two-Yr. College Group	Ex-University Group
English	2 hours	2 hours
Education	4 hours	4 hours
Psychology	—	2 hours
Social Science	2 hours	2 hours
Physical Education	1 hour	1 hour
Hygiene	1 hour	1 hour
Mathematics	3 hours	3 hours
Biology	—	2 hours
Physics	4 hours	2 hours
Chemistry	5 hours	3 hours
Science Teaching Method	1 hour	1 hour
Totals	23 hours	23 hours

In 1951 the two groups, the second year following the wholly College course and the ex-University, were amalgamated into one section for those courses scheduled for the same number of hours each week. Through wastage during and at the end of the first year only ten students remained in the two-year College course, while the ex-University group numbered fifteen, with the result that it would have been uneconomic to treat them, in all courses, as two separate sections. Thus for much of the course work and for all the demonstration lessons and practice teaching the two groups functioned as one section.

The Separate Courses for Ex-University Students

In the two-hour Physics lecture course the opportunity was taken to revise and extend the content of the usual University first level courses in the various divisions of the subject. The two-hour Biology course was devoted partly to lectures and partly to laboratory work. Where deemed advisable, because of the varied background

of the individual students in this science, differentiated activities and assignments were utilized. The general purposes of this Biology course were to prepare, as adequately as possible, each student for the teaching of General Science and to give that knowledge of the subject considered essential in a program of general education.

The time available for the special Chemistry course for these ex-University students was given over partly to lectures, partly to group discussions, and partly to individualized assignments and laboratory experiences after a preliminary survey had revealed the group and personal standings in subject matter knowledge and experimental techniques. The topics treated in the lecture course included atomic and molecular structure, electronic theory of valence, nuclear phenomena, the periodic classification, the electrochemical series, corrosion, the more important metals and large scale chemical processes—the emphasis being placed upon general principles rather than upon minute factual details. In the laboratory the students were engaged in the performance of experiments and exercises which were designed primarily for the development and strengthening of techniques of importance to the teacher of chemistry.

Summary

The great majority of the persons in training for teaching posts in the public schools of New South Wales complete their academic and professional preparation while holding scholarships awarded by the State Department of Education. These scholarships entitle the holder to free tuition, monetary allowances, the loan of the necessary textbooks and other advantages including placement in a teaching position in return for an undertaking to serve anywhere in the State for a few years.

The Sydney Teachers' College operates three programs for the preparation of science teachers for public secondary schools. In the first of these the students complete their studies for the degree of Bachelor of Science in the University of Sydney and then, in the College, devote a year to courses in professional subjects, to attendance at demonstration lessons and to practice teaching leading to the post-graduate Diploma in Education. Students who complete this combined degree-diploma program qualify for the teaching of science at the senior secondary school level.

Two plans exist for the preparation of persons qualified to teach junior secondary school science. In one of these students coming from the secondary schools with good qualifications in Physics and Chemistry complete a two-year course wholly within the College. Under the other plan persons who have undertaken university studies in science subjects, as Teachers' College scholars or as private individuals intent on entering some profession other than teaching, complete at the College, a program devoted principally to professional subjects and activities and closely resembling that of the second year of the two-year College plan.

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THE READING DIFFICULTY OF TEXTBOOKS FOR HIGH-SCHOOL PHYSICS

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INTRODUCTION

The levels of reading difficulty of textbooks and other instructional materials have long been a problem in the teaching of children in the public schools. Several articles devoted to this problem have appeared recently.[1, 2] The following conclusions were made in them: (1) the reading levels of many textbooks are far too advanced for the students for whom they were written, (2) the failure of many students to achieve in subject-matter areas may be caused partly by the levels of reading difficulty of the textbooks in these areas, (3) the levels of reading difficulty of textbooks within any subject-matter area differ greatly, (4) teachers should select textbooks using the levels of reading difficulty as a criterion, and (5) publishers need to take greater cognizance of the levels of reading difficulty of the textbooks they produce.

A search through the literature indicates, however, that there have been made a great number of investigations with respect to the levels of reading difficulty of textbooks and instructional materials within certain subject-matter areas. Among these published materials, those in the field of science have received great attention.

A "milestone" among these investigations was the major one by Curtis.[3] In his investigation he summarized the results of one hundred investigations in the problems of vocabulary related to the teaching of science. His findings provide evidence that substantiates and extends the conclusions of both Kerr and Yoakum. In essence, his conclusions are these:

1. Pupils encounter in science textbooks many technical and non-technical words the meanings of which they do not know.
2. There is insufficient provision in science textbooks for repetition of difficult scientific terms.
3. Too large a percentage of the difficult words in such textbooks are non-scientific or non-technical.
4. Too small a percentage of the scientific terms that are introduced into such textbooks of science are defined.

More recently there appeared three articles[4, 5, 6] that dealt with the reading levels of textbooks for elementary science, junior-high-school science, and high-school biol-

[1] Margaret Kerr, "Use of Readability Formulas in Selecting Textbooks." *Elementary School Journal,* XLIX (March 1949), 411–14.

[2] Gerald A. Yoakum, "Reading Difficulty of School Textbooks." *Elementary English Review,* XXII (December 1945), 304–9, 333–36.

[3] Francis D. Curtis, *Investigations of Vocabulary in Textbooks of Science for Secondary Schools.* Boston: Ginn and Co., 1938. Pp. viii+127.

[4] George Greisen Mallinson, Harold E. Sturm and Robert E. Patton, "The Reading Difficulty of Textbooks in Elementary Science." *Elementary School Journal,* L (April 1950), 460–3.

[5] George Greisen Mallinson, Harold E. Sturm and Lois M. Mallinson, "The Reading Difficulty of Textbooks in Junior High School Science." *School Review,* L (December 1950), 536–40.

[6] George Greisen Mallinson, Harold E. Sturm and Lois Marion Mallinson, "The Reading Difficulty of Textbooks for High-School Biology." *The American Biology Teacher,* XII (November 1950), 151–6.

ogy. In these studies a different technique, that developed by Flesch,[7] was used for evaluating the levels of reading difficulty of the textbooks. The findings from these three studies were similar to those of Curtis. However, it is significant that these investigations were performed on textbooks published approximately twelve years later than those in the Curtis study. Hence, the findings of the earlier investigation apparently have not been universally heeded.

However, the search through the literature failed to reveal any investigations of the reading difficulty of textbooks in the field of high-school physics. Thus, it would seem at this time that such a study would be of value. Hence, it is the purpose of this study to evaluate textbooks for high-school physics with respect to their levels of reading difficulty.

METHODS EMPLOYED

It was decided, as with the last three studies cited, to use the Flesch[8] formula for evaluating the textbooks. The Flesch formula is based on the assumption that the reading difficulty of material depends on the number of words in the sentences, the relative number of personal references (*I, you,* etc.) in the material, and the number of affixes and suffixes (syllabification) to the words. These various aspects are measured, using a one-hundred-word sample of the material, and are translated into a reading-difficulty score by means of a formula. This reading-difficulty score is converted, in turn, into a grade-level value of reading difficulty.

Table 1 contains the information for making this conversion.

A search was then made to locate the titles of textbooks designed for use in high-school physics. The search revealed sixteen such texts. All of them were used in this investigation. Since an analysis of all of the textual material in all of the textbooks was impractical, it was decided to use a modification of the sampling technique suggested by Flesch for use with his formula. Hence, it was decided to select for analysis from each textbook one sample passage for each one hundred pages or fraction thereof, but not less than five passages from any one textbook.

The number of pages in each text was computed by counting from the first page designated by an Arabic numeral to the last page of the last chapter. Pages upon which were found chapter endings, supplementary activities, and questions were included in the count. The pages upon which were found the indices, glossaries and tables of contents were excluded.

The number of pages thus computed in each textbook was then divided by the number of samples to be taken from the respective textbook. In this way each text-

[7] Rudolf Flesch, *The Art of Plain Talk.* New York: Harper and Brothers, 1946, p. 197.

[8] *Ibid.*

TABLE 1

GRADE LEVELS OF DIFFICULTY EQUIVALENT TO READING-DIFFICULTY SCORES*

Reading-Difficulty Scores	Description of Style	Grade Level of Difficulty
0–1	Very easy	4th grade COMPLETED
1–2	Easy	5th grade COMPLETED
2–3	Fairly easy	6th grade COMPLETED
3–4	Standard	7th or 8th grade level
4–5	Fairly difficult	2 years of high school
5–6	Difficult	High school and some college
6 and up	Very difficult	College COMPLETED

* *Loc. cit.*, p. 205.

book was divided into sections of an equal number of pages. A page was then selected from each of the sections by using a table of random numbers.[9]

A one-hundred-word sample was taken from each page thus selected by counting from the first word of the first new paragraph on that page. If the page contained no reading material the sample was selected from the next page that did. The legends under the illustrations on the pages thus selected were disregarded. These samples were then analyzed using the Flesch formula.

Table 2 lists the following information for the textbooks designed for high-school physics: (1) the textbook publishers (designated by the letters A, B, C, etc.); (2) the reading-difficulty scores of the samples taken from textbooks; and (3) the average reading-difficulty score for each textbook.

[9] Quinn McNemar, *Psychological Statistics.* New York: John Wiley and Sons, 1949. Pp. vii+364.

Table 3 that follows lists the designations of the book publishers and the grade levels of difficulty of the respective textbooks.

A survey of the data from Tables 2 and 3 indicates that the levels of reading difficulty of the textbooks for physics vary greatly. But, there is no evidence in these tables to indicate that the differences between the levels of difficulty of the easiest and most difficult textbooks are significant. Hence, it was decided to compute the significances of the differences between the levels of reading difficulty of the easiest and most difficult texts. Thus the books were classified into four groups according to ascending order of difficulty. The first group (1) consisted of the four "easiest" books; the second group (2) of the next four with respect to difficulty; the third group (3), the next four; and the fourth group (4) of the four most difficult. Significances of differences in levels of difficulty were then computed between the books in groups 1 and 2, groups 2 and 3,

TABLE 2

LEVELS OF READING DIFFICULTY FOR TEXTBOOKS FOR HIGH-SCHOOL PHYSICS

Publisher	Reading Difficulty Scores Sample									Average Reading-Difficulty Score for Each Book*
	1	2	3	4	5	6	7	8	9	
A	4.59	1.69	3.02	4.32	2.66	2.86	3.61	4.18	1.93	3.207
B	2.94	1.75	2.85	3.12	4.12	5.26	3.82			3.409
C	5.22	2.00	3.12	4.46	2.22	4.07	3.83			3.560
D	4.06	2.39	3.51	3.15	4.52	3.99	4.01			3.661
E	3.54	3.18	4.25	2.99	3.58	4.80	4.25			3.798
F	4.55	4.34	2.42	3.71	4.65	4.45				4.020
G	4.59	4.20	3.16	3.61	3.55	5.48	3.78			4.053
H	6.11	3.69	4.07	4.18	3.28	6.12	3.28	3.00		4.216
I	2.86	2.27	2.35	4.40	5.80	5.04	6.90			4.231
J	5.48	3.80	4.73	2.93	4.65					4.318
K	5.21	5.86	4.07	3.88	5.80	4.65	1.89			4.494
L	3.71	4.39	4.10	5.49	5.25					4.588
M	4.78	5.81	3.25	4.63	4.57	3.58	4.05	6.25		4.615
N	6.31	4.58	2.64	3.66	4.91	6.18	6.12	3.60		4.750
O	5.00	6.19	5.41	5.25	3.79	6.31				5.325
P	4.90	8.52	5.30	6.05	6.60	4.59	6.27			6.033

* The average reading-difficulty score for all of the textbooks for physics is *4.241* which is equivalent to a grade level of difficulty of ninth grade.

TABLE 3

GRADE LEVELS OF DIFFICULTY FOR TEXTBOOKS IN PHYSICS*

Publisher	Grade Level of Difficulty	Publisher	Grade Level of Difficulty
A	7th grade	I	9th grade
B	7th grade COMPLETED	J	9th grade COMPLETED
C	8th grade	K	9th grade COMPLETED
D	8th grade	L	10th grade
E	8th grade COMPLETED	M	10th grade
F	9th grade	N	10th grade COMPLETED
G	9th grade	O	High school COMPLETED
H	9th grade	P	College COMPLETED

* Grade levels of difficulty were computed by using data from Table 1.

and groups 3 and 4. The statistical device employed was Fisher's "t" cited by Guilford.[10]

Table 4 lists the significances of the differences computed in the manner just stated.

CONCLUSIONS

In so far as the techniques used in this study may be valid, the following conclusions seem justified:

1. The data in Tables 2 and 3 indicate that the average grade levels of reading difficulty of various textbooks for physics vary greatly. The easiest textbook has a grade level of reading difficulty of seventh grade; the most difficult of college completed. The average grade level of difficulty of all of the textbooks is ninth grade.

2. The data in Table 2 indicate that within the individual textbooks for physics there is a great variation in level of reading difficulty. For example in the textbook of publisher A the easiest passage (difficulty score—*1.69*) is equivalent to a grade level of difficulty of fifth grade; the most difficult passage (difficulty score—*4.59*), of ninth grade completed. In the textbook of publisher K the easiest passage (difficulty score—*1.89*) is equivalent to a grade level of difficulty of fifth grade completed; the most difficult passage (difficulty score—*5.86*), of college level.

3. The data from these tables indicate that there are passages in twelve of the sixteen textbooks having difficulty scores of *5.00* or higher. This score is equivalent to a grade level of reading difficulty of approximately the junior or senior year of high school or higher. Since courses in physics are usually designed for juniors or seniors in the high school, it is likely that these passages will cause some difficulty for all but the best students. They are likely to cause great difficulty for the less able ones.

4. In the textbooks of publishers O and P all but three of the thirteen passages that were analyzed would cause difficulty for nearly any student in the high school.

5. The data in Table 3 indicate that there are five textbooks of the sixteen whose *average* level of difficulty is tenth grade or higher. These textbooks in gen-

[10] Joy P. Guilford, *Psychometric Methods.* New York: McGraw-Hill Book Co., Inc., 1936, pp. 61–2.

TABLE 4

SIGNIFICANCES OF DIFFERENCES BETWEEN LEVELS OF READING DIFFICULTY OF TEXTBOOKS FOR PHYSICS

Groups Compared	Mean Difference	σ Difference	"t"	Probability Level	Interpretation
1 and 2	.588	.2135	2.75	$P<.01$	Very Significant
2 and 3	.365	.3020	1.21	$P>.05$	Not Significant
3 and 4	.747	.3487	2.14	$.05>P>.01$	Significant

eral are likely to be very difficult for the less able student, cause some difficulty for the average student, and except for the two most difficult are not likely to be difficult for the better student. The easiest eleven are not likely to be difficult for any but the least able students taking physics.

6. As compared with textbooks for elementary science, junior-high-school science and high-school biology, the textbooks for physics are not likely to be as difficult for the grade level of student for whom they are designed.

7. The data in Table 2 indicate that the earlier passages of the textbooks are not likely to be less difficult to read than the later passages. Hence, in these textbooks there seems to be no provision evident for the growth of reading ability during the school year.

8. An examination of the data in Table 4 indicates that the textbooks in the "easiest quarter" differ significantly in reading difficulty from those in the second and third quarters. Those in the second quarter do not differ significantly with respect to reading difficulty from those in the third quarter. Those in the "difficult quarter" differ significantly from those in the third quarter. These differences are identical with those found between the easiest and most difficult textbooks in biology. It seems defensible to state therefore that the level of reading difficulty is a valid criterion for evaluating a textbook in physics.

9. In summary, the following may be stated:

(a) The textbooks (eleven in number) whose grade level of reading difficulty is ninth grade completed or below (difficulty score below *4.5*) are not likely to be difficult for the average eleventh- or twelfth-grader taking physics. Neither are they likely to cause great difficulty for the below-average student. This conclusion does not apply to individual passages that are difficult.

(b) The textbooks (three in number) whose grade level of reading difficulty is between ninth grade completed and tenth grade completed (difficulty score—approximately *4.5* to *4.75*) are not likely to be difficult for the better student, are not likely to cause great difficulty for the average student, but are likely to be difficult for the less able student.

(c) The textbooks (two in number) whose grade level of reading difficulty is high school completed or higher are likely to be difficult for even the superior student. The most difficult textbook seems to be above the level of comprehension of even some college students.

ARE OUR SCHOOLS PREPARING FOR THE SCIENTIFIC AGE?

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WE hear all about us that this is the age of science. Only recently, however, I heard two eminent men in the fields of science and science education decry the reduced enrollments in science in our junior and senior high schools. They gave most interesting and all too well known statistics on the trend of enrollments in science and spoke of the great danger we face as a nation in the shortage of trained scientists, and the likelihood of a future untrained population living in an age of science.

When we consider the fact that we are also living in an age of entertainment—movies, radio, television, comic books, etc. —there should be little wonder that children are detracted from the rigorous school work as it is presented by most teachers of science today. Science to the average child is a bug-bear. The mere suggestion of the subject connotes something cold and uninteresting—something that is mastered only with great difficulty and by individuals with unusual abilities.

We in the field of science education are forgetting or ignoring one of the basic laws of learning—that of interest. Too many teachers of science like to gloat over the fact that their subject is difficult and can be learned only by individuals with high intelligent quotients and only after much hard study and experimentation. They teach as if they are to turn out specialists, ignoring too frequently the average child and causing him to lose interest and often to drop out of school because of failure. Specialization has no place in the average high school as it is organized today. Even in the technical high school individuals who specialize are often offered jobs in industry in spite of their limited specialization, so great is the demand. Such utilization of almost raw recruits prevents many students from going on to college where they might have prepared for major positions—positions which would have been more conducive to America's leadership in an age of science.

The public schools must play a greater role in getting more young people interested in science and stimulating more of them to go on to college where there are better facilities for specialization. And for those who are not to become specialists, the high schools must prepare them at least to appreciate the basic principles of science.

The major factors involved in the lack of interest in scientific subjects are the conditions under which they are taught and the methodology. The overcrowded classes, the tendency to teach by charts alone rather than by use of actual specimen and apparatus, the loss of the double or longer laboratory period, and the tendency to teach science in isolation from other subjects are all important factors. The teachers of science should deplore these conditions particularly the loss of the double laboratory period. They should not acquiesce to them on either the grounds of economy or of administrative expediency. Science plays too important a part in the lives of individuals for us to compromise on these grounds. The studies made by a few science educators on the relative importance of the laboratory versus the lecture-demonstration and other methods may have been in some measure responsible for the loss of the double laboratory period, but such studies have been too few and conditions of experimentation too varied to justify this drastic change.

Individuals who favor the change might argue that students who were trained under the five period plan have done well in colleges throughout the country. This may be so, but such students would probably have done well even without any science training in high school. We must consider the large numbers who got a poor or inadequate scientific background for everyday living and the numbers that might have been stimulated into some scientific endeavor with the desire to go on to college for further training.

A trend away from the double laboratory period means a trend away from laboratory work. According to Curtis, who is probably the outstanding authority in the field of science education, "That such a development is not justified is amply revealed by unquestioned research evidence. But neither this evidence nor the militant support for the retention of the individual method and the persistent opposition to its reduction from university scientists and leaders in the teaching of science has halted, if indeed it has appreciably retarded, the trend away from individual laboratory work in high school science courses." [1]

Quite alarming is the prospective dearth of scientifically trained individuals needed to carry on for America if she is to maintain her position in technological developments. But equally alarming is the prospect of an American populace without the scientific spirit and an appreciation of things scientific.

[1] Francis D. Curtis, "Individual Laboratory Work Must Be Retained." *The Science Teacher* (April, 1950), p. 82.

THE SELECTION AND TRAINING OF FUTURE SCIENTISTS III

Hypotheses on the Nature of "Science Talent" *

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In the attempt to clarify problems which would be useful in determining the direction of investigations on the nature of the high-level ability which has been called "science talent" one is struck by the paucity of published observations which would serve to define the trait, if indeed, there be one. There is the assumption in the literature, sometimes implied, at other times stated, that there is such a trait and furthermore that such a trait might be measured [1, 3, 5]. The assumption appears to rest on still other assumptions, e.g. if many individuals have had similar opportunities and incentives to develop a trait and if they do so at different rates, then the differences which can be measured among them (in rates of development of the given trait) are differences in "capacity." In this case, it is a difference in capacity to deal with scientific phenomena. Clearly this would hold more for the situation where two identical twins are compared, less for siblings, less for students in a single classroom with a single teacher, less for an entire school, and far less for a comparison of schools in a city, state, or country. Nevertheless, there is a tendency to compare students in regard to their gifts without regard to their opportunities and incentives.

Be that as it may, to investigate a trait, or better, an element in behavior which we may call "science talent," we need to be able to define it so that we may observe it. If we define the trait arbitrarily then we limit our observations. If we do not define it we run the risk of not knowing what to observe. We are, however, on relatively safe ground to begin with if we admit that we are operating in an ambiguous area, that an investigator may at least state his hypotheses to his own satisfaction provided they are not ambiguous to him and proceed to test them in light of clearly understood operations. As he learns more and more, his hypotheses and observations clarify themselves, one in counterpoint to the others. It may be assumed, however, that once the trait is operationally definable, and operationally observable, it may be possible to test it (that is, it may become operationally scorable) [9].

At Forest Hills High School we have been observing the characteristics of students with high level ability in science and mathematics. Some 60 out of 400 of these students have been studied already as they proceeded through high school, into college and into scientific work in engineering, medicine, dentistry, and the various fields of research. There are other observations on these 400 students who have shown this high level ability. On the basis of these observations the writer was confronted with several hypotheses on the nature of "science talent". These may be worth examining.

Hypothesis One might be stated somewhat as follows: There is a trait called "science talent"; it is as clearly definable as musical or artistic talent. This trait is not necessarily a component of high general intelligence.

Hypothesis Two might be stated this way: There is no single trait called "science talent"; high level ability in science (science talent) is a function of high general intelligence.

Hypothesis Three might be stated somewhat this way: There is a trait "science talent" but it is either a component of high general intelligence or masked by it.

Other hypotheses will occur to workers in the field and indeed their publication

* Brandwein, Paul F. Selection and Training of Future Scientists II. Origin of Science Interests. *Science Education* 35:251–253, December, 1951.

should be welcome as serving to direct future observation.

Thus far, the writer's observations have not clearly tended to rule out any of the hypotheses stated although the weight of his observations tend to favor Two [4, 6, 7, 8].

When one studies the lives of scientists of the first rank (operationally defined as Nobel Prize Winners and pre-Nobel scientists of the rank of Newton, Galileo, Koch, Pasteur, Planck), there is a tendency to favor Hypothesis Three. Unfortunately one cannot estimate the opportunities and incentives underlying the operationally observable "science talent" of these scientists. Also, implied in the term first rank is the idea of 2nd, 3rd, 4th, and 5th rank, etc. In other words, if "science talent" is an entity in men of high general intelligence, then "it", or general intelligence, or early opportunities and incentives are variables to be considered in the operationally observable "science talent" of those scientists of lesser rank.

Rank in science may well follow the normal curve of distribution as is the case with most areas of behavior for which data are available. A profitable though exceedingly difficult line of investigation would be to isolate the various elements which go into making a scientist of the first rank and to see whether certain of these elements are lacking in scientists of lesser rank.

Certain observations made since describing earlier ones [8] tend to support the hypothesis stated therein (similar to No. 2 stated here). It seems that those who tend to favor scientific research per se (by seeking, or declaring their intentions of seeking) a doctorate of philosophy in science rather than work in the applied sciences such as engineering, medicine, and dentistry tend generally to give a picture of introversion rather than extroversion. They tend generally to have selected science as a career earlier than those who go into the applied sciences, tend generally to have higher scholastic records (ranking in class), tend generally to be able to need less assistance in selecting problems for project work, tend generally to show higher ability in mathematics, tend to show a generally greater preferment for classical music, chess, and individual rather than team sports (e.g. tennis rather than basketball) than those who go into the applied sciences. They also tend to show high level ability earlier, (they read earlier, they are "early bloomers") than those who tend to go into the applied sciences.

Anomalous to this picture and that described in an earlier paper [8], is the student who may be called the hobbyist in science, or the inventive type (the collector of insects, the radio enthusiast) who tends to show high success in one limited field, but may show relatively poor success in scholastic achievement, even in science. A group of these students is being studied but none of this group has as yet been graduated from college.

These are clearly observable trends in an increasing number of cases already studied through graduate work but the number is not sufficiently high (about 60 of the 400 students mentioned) to report the observations as conclusive.

The place of the scientist in society being what it is, a study of what underlies high level ability in science should occupy a high priority in our investigations.

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THE UNDERGRADUATE PREPARATION OF HIGH SCHOOL CHEMISTRY TEACHERS, ALABAMA, 1948–1949 [1]

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SINCE the high school chemistry teacher occupies a key position in chemical education his own training is of considerable importance. This report gives the results of a study made on the undergraduate preparation in chemistry, physics, and mathematics of the chemistry teachers in the white high schools, both public and private, of Alabama for the year 1948–1949. That year, instead of the later one of 1949–1950, was chosen in order to have the maximum number of chemistry teachers. Some schools teach chemistry only every other year and 1948–1949 was the year in which they taught the subject.

There was found a total of 195 chemistry teachers. The data were obtained mainly from the official college transcripts on file at the State Department of Education,[3] to some extent from the accreditment reports sent in by the high schools, and in a few cases from the original college records. Complete records, including transcripts, were found for 167 of the teachers.

Undergraduate credit in chemistry ranged all the way from 0 to 61 semester hours. In physics the range was from 0 to 20 semester hours and in mathematics from 0 to 29. Table 1 shows, in 5 semester hour steps, the number of persons having credit in these subjects. The percentages given in this and the other tables are all based on a total of 195. The number of persons for whom information was found varied from one item to another, therefore the number of persons shown varies from one table to another and usually does not equal 195 and the total percentage usually does not equal 100.

TABLE I

Sem. Hrs. Credit	Teachers having credit in Chemistry No.	%	Physics No.	%	Math No.	%
0	18	9.2	64	32.8	46	23.6
1–5	6	3.1	24	12.3	18	9.2
6–10	50	25.6	72	36.9	63	32.3
11–15	33	16.9	3	1.5	10	5.1
16–20	30	15.4	4	2.1	13	6.7
21–25	12	6.2	0	0	12	6.2
26–30	10	5.1	0	0	5	2.6
over 30	8	4.1	0	0	0	0
Totals	167	85.6	167	85.6	167	85.7

The numbers of hours of credit that occurred most frequently in chemistry were 8 hours (21 persons), 6 hours (19 persons) and 12 hours (17 persons). In physics 30 persons had 8 hours credit and 23 had 6 hours. In mathematics 37 persons had 6 hours and 9 persons had 10 hours.

Table II shows the number of teachers who had certain courses and certain combinations of courses in chemistry, without regard to the amount of credit. This table shows that 44 of the teachers had general chemistry and no other course in the subject and that 40 had qualitative analysis regardless of what other chemistry courses they had. Only 4 had the well-rounded undergraduate program of general, qualitative and quantitative analysis, organic, and physical chemistry. In addition to these, 14 others had general, qualitative and quantitative analysis, and organic. In all except the first three cases the number of persons listed is the number who had that course or combination regardless of what other courses in chemistry they had.

[1] Presented before the Division of Chemical Education at the 118th meeting of the American Chemical Society at Chicago, Illinois, September 4, 1950.

[2] Present address: Mississippi State College for Women, Columbus, Mississippi.

[3] The authors wish to thank Dr. Morrison McCall of the Alabama State Department of Education for permission to use these records.

TABLE II

Course or combination	No. of teachers	%
Gen. chem. only	44	22.6
Gen. and qual. only	6	3.1
Gen. and organic only	22	11.3
Qualitative	40	20.5
Quantitative	32	16.4
Organic	76	39.0
Physical	11	5.6
Gen., Qual., Quant. and Organic	14	7.2
Gen., Qual., Quant., Organic, and Physical	4	2.1

Table III gives the number of teachers whose transcripts showed no undergraduate credit in chemistry, physics, and mathematics and the combinations of these subjects. For example, it shows that 7 teachers had no chemistry, physics, or mathematics, that 6 had no chemistry or physics

TABLE III

Subject or combination	No. of teachers with no credit	%
Chem., physics, math	7	3.6
Chemistry, math	0	0
Chemistry, physics	6	3.1
Physics, math	14	7.2
Chemistry	5	2.6
Physics	37	19.0
Math	23	11.8

but did have some mathematics, and that 5 had no chemistry but did have some credit in physics and mathematics.

Of 192 of the teachers for whom the information was available, 97 were men and 95 women. Some figures on the extent of undergraduate training of men and women teachers in the fields of chemistry, physics and mathematics are given in Table IV. These figures indicate that the women had somewhat more training in chemistry, less training in physics, and considerably less training in mathematics. These differences might be accounted for to some extent if very many of the women teachers had majored in home economics or medical technology in college.

It should be mentioned that the amount of credit shown is always the minimum, and in some cases might be less than the actual amount. A teacher could have continued his studies without the record of it being available. Also, this study dealt only with undergraduate work and at least 38 of the teachers held master's degrees and in many instances the graduate work included some further training in chemistry, physics, or mathematics.

TABLE IV

Sem. hrs. credit	Chemistry Men	Chemistry Women	Physics Men	Physics Women	Math Men	Math Women
0	12	4	30	32	10	36
1–5	5	1	7	16	11	7
6–10	29	22	47	26	45	18
11–15	11	22	3	0	6	3
16–20	16	12	1	2	6	6
21–25	6	6	0	0	7	5
26–30	5	5	0	0	3	1
over 30	4	4	0	0	0	0
Totals	88	76	88	76	88	76

ACHIEVEMENT OF TWINS IN SCIENCE *

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The Problem

NUMEROUS studies have been made regarding the resemblance of twins in physical and mental characteristics, but few studies have been concerned with the resemblance of twins in academic achievement in specific areas. As part of a comprehensive study of science instruction in fifty-six Minnesota high schools,[1] the writer was able to identify several pairs of twins taking high school biology and chemistry. The problem then became one of establishing the resemblance of these twins in the various aspects of biology and chemistry instruction as measured by the examinations used.

Selection of the Sample

The biology students and chemistry students in the study had been asked to indicate their age, date of birth, sex, and grade in school as part of the testing program. Papers with the same name, age, grade in school, and date of birth, were separated from the 1980 papers and the 13–52 papers in biology and chemistry. Since not all of the students so identified had provided all the information requested, it was necessary to send out letters to the schools for the twenty-one twin suspects in biology and the eighteen twin suspects in chemistry. Verification was definitely established in the case of eight like-sex twins and three pairs of unlike-sex twins in biology. Verification was definitely established in the case of seven pairs of like-sex twins and two pairs of unlike-sex twins in chemistry. The classification of the twins into fraternal or identical categories was impossible in terms of the information received.

In order to establish more adequately the twin resemblance in achievement in biology and chemistry, control groups of unrelated pairs of individuals were selected at random from the total group. Thus the control group for biology had eleven pairs of unrelated individuals which were selected from the same classes in which the twins were enrolled. The unrelated pairs in no case had the same name, thus ruling out the possibility that the pairs selected were siblings.

Achievement Factors Considered

In addition to Otis I.Q.'s the following test data were available: (1) total scores on the biology and chemistry final examinations; and (2) part scores on the final examinations. The part scores represented achievement in (a) factual information, (b) biological or chemical principles, (c) elements of the scientific method in biological or chemical situations, and (d) scientific attitudes.

The validity of the examinations was established by correlating the total scores against such criteria as teachers' marks and the scores on established tests in biology and chemistry. The reliabilities of the parts and of the total examinations were determined by using Hoyt's analysis of variance method. The reliabilities of the parts, although not high in all instances, were significant at the 1 percent level, indicating a correlation greater than zero. The correlation for the whole test was .92 in biology

* Reprinted in part, by permission, from the *Journal of Experimental Education,* 19:261–266, March, 1951.

[1] Kenneth E. Anderson. *The Relative Achievements of the Objectives of Secondary School Science in a Representative Sampling of Fifty-Six Minnesota Schools,* Doctor's Dissertation, University of Minnesota, Minneapolis, Minnesota, 1949.

and .91 in chemistry. Thus, the scores used in this analysis may be considered to have been obtained by the use of valid and reliable examinations.

Statistical Analysis

For data of this kind, Johnson[2] recommends the method of analysis of variance by which one may obtain the intraclass correlation (r′). It is possible to separate the variance of a sample into two parts, (a) one arising from the natural variation of individuals treated alike, and (b) the other arising from the environmental or genetic conditions existing in the subsamples. The sum of (a) and (b) is the variance of the individuals chosen at random from the population sampled. Intraclass correlation is a ratio of two of the variances stated above, namely, $\frac{b}{a+b}$. Since r′ is a ratio of two variances, we are justified in calling this ratio correlation.

The technique of analysis of variance with the resulting intraclass correlation was applied on the twin and control groups for six sets of scores representing: (1) the Otis I.Q., (2) the acquisition of factual information in biology or chemistry, (3) the understanding of biological or chemical principles, (4) the understanding and application of the elements of the scientific method in biological or chemical situations, (5) the acquisition of scientific attitudes, and (6) the combined achievement in biology or chemistry as represented by the total examinations.

Statistical Results

An examination of the calculations allows us to draw the following conclusions regarding intelligence:

(1) The I.Q. of an individual is not independent of the *twin pair* to which he belonged or the intraclass correlation between twins significantly greater than zero. The intraclass correlation for all twin pairs was .50 for biology and .61 for chemistry. When the unlike-sex twins were removed the correlations became .63 and .86 respectively.

(2) The I.Q. of an individual was independent of the *unrelated* pair to which he belonged or the intraclass correlation was not significantly greater than zero. The intraclass correlations for the unrelated pairs of the control group were .19 and —.31 for biology and chemistry respectively, neither correlation being significant at the 5 percent level.

An examination of the calculations for biology allows us to draw the following conclusions:

(1) The achievements of an individual in biology were not independent of the twin pair to which he belonged or the intraclass correlations were significantly greater than zero at the 5 or 1 percent level for all twin pairs for all parts of the test and total test, except in the case of acquisition of factual concepts. This was not true for the control group of unrelated individuals, except in the case of acquisition of scientific attitudes, where a significant intraclass correlation of .51 at the 1 percent level was obtained.

(2) The intraclass correlations for all twin pairs were as follows: .43 for factual concepts, .81 for understanding of principles, .54 for understanding and application of the scientific method, .59 for acquisition of scientific attitudes, and .71 for total understanding and acquisition in biology.

(3) The intraclass correlations for the same abilities with unlike-sex twins removed were as follows: .65, .98, .51, .52, and .76. The correlations of .65, .98, and .76 were significant at the 5 or 1 percent level and were of greater magnitude than was the case for all twin pairs. The correlations of .51 and .52 were not significant at the 5 percent level and of less magnitude than was the case for all twin pairs.

An examination of the calculations for

[2] Palmer O. Johnson. *Statistical Methods in Research* (New York: Prentice-Hall, Inc., 1949), p. 226.

chemistry allows us to draw the following conclusions:

(1) The achievements of an individual in chemistry were not independent of the twin pair to which he belonged or the intraclass correlations were significantly greater than zero at the 5 or 1 percent level for all twin pairs for all parts of the test and total test except in the case of the understanding of principles, and the acquisition of scientific attitudes. This was not true for the control group of unrelated individuals where all of the intraclass correlations were not significantly greater than zero.

(2) The intraclass correlations for all twin pairs were as follows: .68 for acquisition of factual concepts, .41 for understanding of principles, .53 for understanding and application of elements of the scientific method, .51 for acquisition of scientific attitudes, and .59 for total acquisition and understanding in chemistry.

(3) The intraclass correlations for the same abilities with unlike-sex twins removed were as follows: .37, .68, .39, .31, and .45. Only one of these correlations was significant at the 5 percent level. This was the case on the understanding of principles of chemistry and represents an increase over the correlation for all twin pairs.

General Conclusions

It has been clearly demonstrated by the results of this investigation that intelligence of an individual, as represented by the Otis intelligence quotient, was not independent of the twin pair to which he belonged, and that when the unlike-sex twins were removed, an increase in the intraclass correlation resulted. This same conclusion was not warranted in the case of unrelated pairs of individuals drawn from the same classes in which the twins were enrolled. These conclusions are no different from those drawn by previous investigators regarding the influence of heredity on intelligence.

It has been demonstrated by the results of this investigation that some of the academic abilities as measured by part examinations and acquired by an individual in a year of study, were not independent of the twin pair to which he belonged. This was especially true in case of the ability to understand and apply the principles of biology and chemistry. This ability is generally recognized by most science educators to be an important objective of science instruction. The same conclusions for the abilities measured by the part examinations are not warranted for the unrelated pairs of individuals in the control groups. The removal of unlike-sex twins raised the intraclass correlations for some of the abilities and lowered the intraclass correlations for other abilities. Not all of the correlations were statistically significant.

It has been demonstrated by the results of this investigation that achievement in biology and chemistry as measured by the total examinations, and as acquired by an individual in a year of study, was not independent of the twin pair to which he belonged. This conclusion was not warranted in the case of the unrelated pairs of individuals drawn from the same classes in which the twins were enrolled. The removal of unlike-sex twins in the biology calculations raised the intraclass correlation from .71 to .76. This was not the case in chemistry where the intraclass correlation became insignificant. Previous studies have demonstrated the resemblance of twins in mental characteristics as measured by intelligence tests. This study substantiates those findings. This study was not primarily concerned with the resemblance of twins in intelligence but with the resemblance of twins in certain defined academic abilities in the fields of high school chemistry and biology. It has been demonstrated by the present study that twins exhibit a high degree of resemblance in the defined academic abilities and that this resemblance is not present in unrelated individuals. One might well raise the question whether these academic abilities are highly related to intelligence. This is true to some degree, as positive correlations ranging from .40 to .70 were obtained when the part-test scores were correlated with the intelligence test

scores. However, for all twin pairs, the total test scores in biology and chemistry produced intraclass correlations of .71 and .59 as contrasted to the intraclass correlations for intelligence quotients of .50 and .61 respectively.

As far as this study is concerned, it is evident that heredity exerts an influence not only in the realm of intelligence but also in the ability to acquire knowledge of science as measured by the examinations used.

A DETERMINATION OF EXPERIMENTS DESIRABLE FOR A COURSE OF GENERAL SCIENCE AT THE JUNIOR HIGH SCHOOL LEVEL; II *

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STATEMENT OF THE PROBLEM

THE purpose of this part of the investigation was to determine the relative values of experiments which are desirable for inclusion in a general science course at the junior high school level; to determine whether each of these experiments would be performed more appropriately as an individual laboratory experiment or as a demonstration; and to determine whether each experiment would be more appropriately performed inductively or deductively.

TECHNIQUES EMPLOYED

The solution of the main problem as stated above involved, first, the completion of two minor problems:

1. To assemble experiments appropriate for use at the junior high school level.
2. To assign these experiments to the various principles of the previously established list.

The experiments used in this work were taken from workbooks and textbooks selected according to the following criteria:

1. They must have been designed for the use of junior high school classes in science.
2. They must have been published not earlier than 1938.
3. They must be the most recent editions available in January, 1949.

From approximately eighty workbooks and textbooks, forty-six were found which met these criteria.

Each book was read page by page and each experiment that, in the opinion of the investigator, satisfied the criteria, was written on a 3″ x 5″ library card. Identical experiments were not recorded but similar experiments were. To illustrate, in many books the pupils were directed to observe the effect of atmospheric pressure on a varnish can from which most of the air had been expelled. One recording of this experiment was deemed sufficient for this investigation. On the other hand, in one book the children were directed to listen to a small bell under a bell jar when the normal amount of air was contained by the jar and again when most of the air had been drawn from the jar. Another book directed the children to perform the same experiment but to use an alarm clock in place of the bell. Both of these experiments were retained and later combined into one experiment with a choice of equipment (a bell or an alarm clock).

After all the books had been examined and the experiments taken therefrom, the experiments were arranged according to topics. Thus, the experiments that dealt with problems in physics were grouped under topic headings such as heat, light, sound, and so on; the experiments in the

* This article is based on one section of the author's dissertation for the degree of Doctor of Philosophy, University of Michigan, 1950. Part I was published in the December, 1951, *Science Education*, Volume 35:279–284.

other fields were similarly grouped under appropriate topic headings.

In assigning the experiments to the various principles, each principle was written on a separate sheet of paper and then below it were recorded the experiments that, in the opinion of the investigator, contributed to an understanding of that principle. By this procedure, 432 experiments were assigned to the principles.

After this preliminary work, the experiments assigned to each principle were considered as a group and repetitious statements were eliminated. After these eliminations, the remaining experiments were recast in question form, in accordance with the inductive method. The following example illustrates how the directions of an experiment were recast in question form.

These were the directions:[1]

> In a tumbler of dilute sulfuric acid place a strip of copper and a strip of zinc. Do not let the strips of metal touch each other. Connect the strips to an electric indicator by wires. What evidence is there of an electric current when the switch is closed? (Diagram)

These were the questions:[2]

> If two strips of copper, each connected to a different terminal of a galvanometer, are thrust into a lemon or are put into a beaker of battery acid, does the galvanometer indicate an electric current is flowing through it? If the experiment is repeated with two strips of zinc, what difference, if any, is found in the result? if then one strip of copper and one of zinc are used, what difference, if any, is found in the result indicated on the galvanometer?

It was believed that, from the former statement, a child could not be expected to infer that two different metals in a conducting solution were necessary for the flow of electricity. In the second statement, however, it is brought to his attention that the presence of two metal strips in a conducting solution does not in all cases cause electricity to flow through a conductor connecting the two strips; but that it does when the two metal strips are of different metals.

The experiments which did not lend themselves to the inductive method of teaching were eliminated from the main body of this work. There were many, though, that were believed to be of value in the deductive method, and, since the deductive method has its own place in the teaching of science, these are presented in Appendix I.[3]

The list resulting from the culling and refining of the preliminary list contained 248 experiments assigned to 109 principles, each of which, it was believed, leads directly, and in a few cases, sufficiently, to the principles to which it was assigned.

There were 103 principles to which no experiments were assigned. These principles are in Appendix II.[4]

EVALUATION OF EXPERIMENTS ASSIGNED TO PRINCIPLES

When the list of principles with the experiments assigned had been completed, it was sent to the four evaluators who had judged the principles. They were given the following directions:

a. State whether or not each experiment contributes to an understanding of the principle to which it is assigned.

b. Indicate, on a 5-point scale, the extent to which each experiment is desirable for a course in general science in the junior high school. On this scale, a highly valuable experiment is to be given the value of 5 and an undesirable one given the value of 1. These judgments of desirability are to be made on the basis of four criteria:

1. The experiment must be safe.
2. It must be simple enough to be comprehended by children in a dull-normal group of the junior high school.
3. It must be capable of being performed with usual, simple equipment.
4. Its performance must be practicable within a thirty-minute lesson period.

c. State whether each experiment would be more appropriately performed as an in-

[1] Samuel P. Unzicker and Benjamin C. Gruenberg, *Activities in General Science*. Yonkers-on-Hudson, New York: World Book Company, 1939. p. 117.

[2] Smith, op. cit. p. 142.

[3] Ibid. p. 172.

[4] Ibid. p. 185.

dividual laboratory experiment or as a demonstration.

The terms used were defined for the evaluators as follows:[5]

The term "experiment" means any kind of activity in connection with which apparatus or materials are manipulated or field trips are made in an attempt to solve a problem in the field of science.

A "laboratory experiment" is one that is pupil-performed for observation only by the performer or performers.

A "demonstration experiment" is one that is performed by a teacher and/or one or more pupils and is for observation by all members of the class.

The results of this evaluation are presented in Table 1.

[5] Vaden Willis Miles, "A Determination of the Principles and Experiments Desirable for a High-School Course of Integrated Physical Science," Unpublished Doctor's Dissertation, University of Michigan, 1947. p. 97.

TABLE I

EXPERIMENTS ASSIGNED TO PRINCIPLES AND THE JUDGMENTS OF THE EVALUATORS AS TO WHETHER EACH EXPERIMENT IS CONTRIBUTORY TO THE PRINCIPLE TO WHICH IT IS ASSIGNED, THE EXTENT OF THE DESIRABILITY OF THE PRINCIPLE, AND THE METHOD BY WHICH THE EXPERIMENT COULD BE PERFORMED MORE APPROPRIATELY

Experiments Assigned to Principles	Judgments Concerning Contribution		Judgments Concerning Desirability	Judgments Concerning Methods	
	Yes	No		Dem.	Lab.
*2. Every body has weight and occupies space.					
Experiments:					
If a drinking glass is thrust mouth downward into water until it is completely submerged, is the glass filled with water completely, only partly, or not at all?	4	0	18	1	3
Does a football weigh more when it is inflated than when it is not?	4	0	17	3	1
4. A gas tends to expand so as to fill all the available space.					
How far away from a gas jet can the odor of gas be detected in a room when the jet has been opened only a little?	4	0	6	4	0
In what parts of the room can the odor of an open bottle of ammonia water be detected?	4	0	16	4	0
In what parts of the room can the smell of a lighted pipe or cigarette be detected?	4	0	7	4	0
5. Warm water is forced up by the settling of cold water.					
If a Bunsen burner is placed beneath one side of a beaker of water with sawdust particles in it, do the particles move upwards or downwards on the remote side of the beaker?	4	0	18	2	2
If sawdust particles are put into a model hot water heater, do they move upwards or downwards in the pipe directly over the source of heat?	3	1	14	2	1
Does the bottom or the top of a home hot water tank become warm first?	4	0	17	2	2
6. In general, bodies expand when heated and contract when cooled.					
If a bolt will just pass through a washer when both are at room temperature, will it go through more easily when the washer is heated or when it is cooled?	4	0	13	3	1

* This table is read thus: 4 evaluators considered this experiment to be contributory to its principle; their total assignments of marks to it was 18, indicating it was desirable; one evaluator thought this experiment could more appropriately be done as a demonstration while 3 thought it could more appropriately be done as an individual laboratory experiment. The numbers here assigned to the principles correspond with those assigned to the same principles in the original work. (Smith, op. cit. p. 60)

If a brass ball is made so that it will just pass through a bronze ring when both are at room temperature, will it go through the ring more easily if it is hotter or colder than the ring?	4	0	16	4	0
If a one-hole rubber in which a tube has been inserted, is pressed into the mouth of a flask full of water so that the water is forced part-way up the tube, will the water level in the tube rise or fall as the water in the flask is heated?	4	0	20	4	0
If a flask is fitted with a one-hole stopper through which a glass tube has been inserted, and if then the flask is inverted and supported so that the end of the tube outside the flask extends below the surface of colored water in a beaker, does the water level in the tube go up or down as the air in the flask is heated gently?	4	0	15	4	0
If a balloon is fastened over the mouth of a milk bottle and the bottle is heated in the sunshine, what happens?	4	0	20	2	2
If a weight is suspended on a wire two feet long, and a yard stick is supported vertically behind the weight so that the distance from the floor to the weight can be determined, does the distance increase, decrease, or remain the same as the wire is heated by a Bunsen burner? That is, does the wire become shorter, longer, or remain the same length as it is heated?	4	0	17	4	0
If a metal rod is balanced on a knife edge when all parts are at uniform temperature and if one end is then slightly heated, will that end rise, descend, or remain where it was?	4	0	11	4	0
7. Water in nature is never pure.					
If four cultures are prepared and one is kept sterile and each of the others has several drops of river water, tap water, and well water placed on its surface, is there any evidence, after several days, that any of the samples of water contained bacteria or other living things?	4	0	19	2	2
If tap water which appears to be pure, is boiled until no water is left, what evidence, if any, is there that minerals were present in the water as impurities?	4	0	18	3	1
8. Every combustible substance has a kindling temperature which may be greater or less than that of another substance.					
If a small piece of wood, a piece of paper, a little sulphur, and a little phosphorus are put on a sheet of galvanized iron about four inches square which is heated by a Bunsen burner, in what order will the substances ignite? What does this experiment indicate with respect to the kindling temperatures of the various substances?	4	0	19	4	0
10. Heat is liberated when a gas is compressed and is absorbed when it expands.					
If a finger is held near the outlet of a bicycle pump while a tire is being filled, does the end of the pump near the air that is being compressed in the tire become warmer, or cooler, or does it remain at the same temperature?	4	0	18	3	1
Does the air escaping from an inflated football or bicycle tube, and therefore expanding, seem to be warmer or cooler than the surrounding air?	4	0	20	2	2
13. When air is cooled sufficiently the moisture in it condenses.					
What is seen on the sides of a shiny metal cup when the cup is cooled by putting a mixture of water and ice in it?	4	0	19	1	3
When a person breathes on a mirror, does it remain clear or is it clouded over with droplets of moisture?	4	0	14	1	3

What forms on eye glasses when a person wearing them enters a warm room from out-of-doors on a cold day?	4	0	14	1	3
If a flask containing water and a little chalk dust is stoppered with a one-hole rubber stopper and if then air is forced into it through the one-hole stopper until the stopper is blown out, what is seen in the flask?	4	0	13	4	0
15. The quantity of water vapor that the air can hold decreases as the temperature decreases.					
What change, if any, occurs on the outside surface of a shiny metal cup, if the cup is first filled with water at room temperature and is then cooled with ice?	4	0	19	2	2
16. Atmospheric pressure decreases as altitude increases.					
If one barometer is placed in the basement and another is placed in the top story of a high building, which barometer indicates the greater pressure?	4	0	20	4	0
18. When light strikes a surface, part of it is reflected from the surface.					
If, in the classroom a mirror is held so that the sun shines on it, is part of the light reflected (turned back) so that it makes a bright spot on the wall or the ceiling in a part of the room that is not illuminated directly by the sunshine?	4	0	16	1	3
19. If a beam of light falls on an irregular surface, the light is reflected in all directions.					
If in a darkened room the beam of a flashlight is directed towards a mirror and then towards a rough white surface such as a plaster wall, is the light reflected from each surface in the same way? How do you know?	4	0	16	3	1
20. When waves strike an object they may be absorbed, transmitted, or reflected.					
Is any light reflected by a mirror held in the hand behind a lighted lamp? Does the mirror absorb any heat from the lamp (become hotter) or does it lose heat (become colder)? or is there no difference noticeable? If a piece of clear glass is put in the place of the mirror, is more or less light reflected than before from the mirror? Does the glass gain or lose heat? Is more or less light transmitted through the glass than through the mirror?	4	0	13	1	3
22. The more nearly vertical the rays of radiant energy, the greater is the number that will fall on a given horizontal area and the greater the amount of energy that will be received by that area.					
If a vertical beam from a flashlight is directed towards a card held horizontally and then the card is tilted, is the area lighted increased, or decreased, or does it remain the same? Is the area illuminated more intensely or less intensely?	4	0	18	4	0
If a flashlight representing the sun throws its light upon the middle of a globe, is the portion when the rays strike vertically more or less intensely lighted than the portions where the light strikes obliquely?	4	0	17	4	0
23. Whenever an opaque object intercepts radiant energy, a shadow is cast by the object.					
If the beam of a flashlight is directed toward a light colored wall and then a ball is placed in the beam, what evidence, if any, is seen that the ball intercepts some of the radiant energy of the flashlight? That is, what evidence, if any, is there that the ball prevents some of the light from the flashlight from reaching the wall?	4	0	16	3	1
If the hand is held close to a lighted Bunsen burner so that heat is felt without discomfort and then a metal plate is	4	0	17	2	2

placed between the hand and the burner, what evidence, if any, is there that some of the radiant energy of the flame is intercepted by the shield? That is, what evidence, if any, is there that the shield prevents some of the heat from going from the flame to the hand?					
24. The color of an opaque object is determined by the wave lengths of the light rays it reflects.					
If a card appears to be white in sunlight, what color does it appear to be when held in a red light? when held in a blue light?	4	0	19	3	1
25. Sound travels only through matter.					
If an electric bell (or an alarm clock or a metronome) is placed in a bell jar and the air in the jar is evacuated, is the sound heard as well, more distinctly, or more faintly?	4	0	16	4	0
26. Sounds are produced by vibrating bodies.					
If a pin is attached to a tuning fork, the fork is struck, and then the pin is drawn over a piece of smoked glass, is the line traced by the pin straight or wavy?	4	0	13	3	1
How does a suspended pith ball behave when a sounding tuning fork is held against it?	4	0	13	3	1
Does a rubber band stretch between the hands and made to vibrate, produce a sound?	4	0	19	1	3
Can a tone be produced by blowing across the mouth of a test tube and thus making the air within the test tube vibrate?	4	0	13	2	2
If a soda straw is cut to resemble an oboe reed and then air is blown through it, do the lips against the straw vibrate? is a tone produced?	4	0	12	1	3
If a knitting needle is driven into a block of wood and made to vibrate, does it produce a sound?	4	0	16	2	2
If rubber bands are stretched around a board, and on one side are kept from touching by a ruler used as a bridge, when the bands are plucked and thus made to vibrate, do they produce sounds?	4	0	18	2	2
27. Regular vibrations produce musical sounds: irregular vibrations produce unmusical sounds (noise).					
If air is forced through holes spaced regularly in a revolving disk, is the tone produced pleasant or harsh? If air is forced through holes spaced irregularly in the revolving disk, is the tone produced pleasant or harsh?	4	0	14	4	0
30. Since the earth rotates from west to east, the exact time at which the sun is nearest overhead grows continually later as one travels westward around the world.					
If, by consulting timetables, the path of a person travelling across the continent is traced on a map, does the traveller seem to lose or gain time going from New York to San Francisco? from San Francisco to New York?	4	0	13	1	3
37. Only topsoil can hold the water and thus retard erosion by running water and wind.					
If a mound of mixed soil is built so that one side is banked with moss or grass sod, and the other side has no such cover, and then water is sprinkled on the mound, does the soil erode more or less rapidly where it is covered with vegetation than where it is bare? If the air current from an electric fan is directed toward this mound, as a wind, does the covered soil or the bare soil erode more rapidly?	4	0	18	3	1
If two boxes are each equipped with a spigot at one end, and if a few inches from the spigots, pieces of wire gauze are placed so as to divide each box into two compartments, and if then in the first box the compartment without the spigot	4	0	16	4	0

is filled with soil and grass, and the similar compartment of the other box is filled with sand, from which spigot is more water collected after an equal amount has been sprinkled on each box?					
38. Various kinds of soils and various depths of soils, contain different amounts of humus.					
If a sample of garden soil and a sample of sandy soil are examined with a hand lens, in which sample is there more evidence of the remains of decayed leaves or other plant life?	4	0	19	1	3
If samples of soil and plant life are taken from a forest floor, will the sample from the surface contain mainly leaves or mainly soil? Will a sample from three inches below the surface contain mainly leaves or mainly soil? Will a sample taken from six inches below the surface contain mainly leaves or mainly soil?	4	0	18	1	3
40. Friction results whenever work is done.					
When work is done by rubbing sandpaper over a board, how do the temperatures of the board and the sandpaper and their surfaces change? In what ways, if any, do these results indicate friction between the board and the sandpaper?	4	0	14	1	3
41. A magnet has at least two poles and is surrounded by a magnetic field.					
If a bar magnet is placed under a sheet of glass and if then iron filings are sprinkled on the glass, and the glass is tapped with a finger, how many poles, as indicated by concentrations of iron filings, become evident?	4	0	14	1	3
How many poles can be found in the magnet in an electric doorbell? In a telegraph sounder?	4	0	12	3	1
If a portion of a strongly magnetized steel needle, two inches from one end is heated red hot and then that portion is twisted suddenly with demagnetized pliers, at how many spots will the knitting needle attract iron filings? Therefore, how many magnetic poles does the needle have?	4	0	13	4	0
If a lodestone is suspended by a thread, how many poles, as indicated by the attraction of a compass needle, will become evident?	4	0	16	3	1
42. Like magnetic poles repel: unlike poles attract.					
Is the N pole of a compass needle attracted to or repelled by the N pole of a magnet? the S pole?	4	0	18	1	3
If a bar magnet is suspended horizontally so as to swing freely, is the N pole attracted to or repelled by the N pole of another bar magnet? by the S pole?	4	0	20	2	2
If four needles, all magnetized with the N pole at the eye, are stuck vertically through four corks and then all are floated in one pan of water, do they come together when all eyes are up? all points up? with two eyes and two points up?	4	0	13	4	0
If two round steel magnets are placed about an inch apart on the table with N poles side by side, do they attract or repel each other? If the S pole of one is beside the N pole of the other, are they attracted or repelled by each other?	4	0	17	2	2
43. Electricity may be produced by friction, by chemical action, or by the use of magnets.					
If one terminal of a door bell is connected to a zinc strip and the other to a copper strip when both strips are in one beaker of battery acid, but not in contact with each other, what evidence is there, if any, that chemical action in the cells is producing an electric current through the circuit?	4	0	17	4	0

Will the bell ring? What do you infer from this regarding the relationship between chemical action and electrical currents?					
If a small generator (such as is used in a manually-operated telephone) is operated, can it light a small lamp connected to it? If the horseshoe magnets, between whose poles the armature rotates, are then removed and the generator is operated, can it light the lamp?	4	0	14	4	0
If two similar lead plates are immersed in battery acid and then one is connected to one terminal of a bell and the other to the second terminal, what evidence, if any, is there that chemical action in the battery is producing an electric current? Will the bell ring? If the bell is disconnected and a direct current is passed through the two plates, still in the acid, by connecting one to the positive pole of two dry cells in series and the other to the negative pole for 15 seconds, does either of the plates change in any way? If so, how? Are the plates then similar or dissimilar? Are the plates when disconnected from the cells and again connected to the bell, as at first, able to ring the bell? What evidence is there, if any, that chemical action in the battery is producing an electric current?	3	1	11	4	0
If the hard rubber plate of an electrophorus is rubbed with fur and the metal plate is charged by placing it on the rubber plate and then removing it, what is seen or felt when a person puts a finger close to the metal plate? What, if anything, passed from the plate to the finger or from the finger to the plate?	4	0	15	3	1
44. Whenever electricity passes through a conductor some of the electrical energy is changed to heat energy and some may be changed to light energy.					
If first a three-inch and then a three-foot length of copper wire is connected across the poles of a dry cell, is more heat developed in the shorter or longer wire?	4	0	11	3	1
If a neon light or a small lamp is connected to a battery so that it glows, is heat generated in the lamp? How do you know?	3	1	11	3	1
If one foot of iron wire is made into a coil and is connected in series with two dry cells and the coil is immersed in a glass of water for 10 minutes is the temperature of the water higher or lower than at first?	4	0	18	3	1
Immediately after a heating coil is connected in a 110-volt circuit, what change occurs in the appearance of the coil?	4	0	15	4	0
45. Like electrical charges repel; unlike charges attract.					
If an uncharged ball is touched by a glass rod that has been rubbed with silk and thus is given a positive charge, will the ball then be attracted or repelled when the positively charged rod is brought near it?	4	0	17	4	0
If one pith ball is given a negative charge by being touched with a charged ebony rod, does it attract or repel another pith ball that has been given a positive charge by being touched with a charged glass rod?	4	0	17	4	0
If an uncharged pith ball is touched with a fountain pen that has been rubbed with a woolen cloth and is thus given a negative charge, will it be attracted or repelled when the pen, with a negative charge, is brought close to it?	4	0	18	3	1
If two rubber balloons are hung side by side and if then each is given a negative charge by being rubbed with a woolen cloth, will they attract or repel each other?	4	0	19	3	1
46. All materials offer some resistance to electrical currents and some of the energy used in overcoming this resistance is transformed into heat energy.					

If a piece of copper wire is connected to the terminals of an ohmmeter (a device that consists of an ammeter and a battery of constant voltage and indicates resistance) is resistance indicated? What difference, if any is felt in the temperature of the wire?	4	0	12	4	0
If one foot of iron wire is made into a coil and connected to the terminals of an ohmmeter, is any resistance indicated? If the coil, still connected, is put into a beaker of water for ten minutes, what change, if any, is found in the temperature of the water?	4	0	14	3	1
55. Every living thing is composed of one or more cells.					
If a piece of skin from between the leaves of an onion and a scraping from the lining of the mouth are examined under a microscope, are cells seen in one sample? in both samples? in neither sample?	4	0	14	3	1
64. Environment causes changes in living things and living things cause changes in environment.					
Is it possible to find wild rabbits in the locality in the fall and then again in the winter? What difference is seen in the coats of those seen in the fall and those in the winter? What change of environment brings about this difference, if there is any?	4	0	12	3	1
If there is a creek in the vicinity and if beavers live in this stream, what evidence can be found that the animals have changed the environment? (field trip)	4	0	15	3	1
After a rain storm what evidence, if any, can be found that earthworms are changing the soil in a lawn or a golf course?	4	0	15	3	1
If a pet, such as a dog or a rabbit is kept out of doors throughout the year, what difference can be observed in the thickness of the animal's coat when it is examined in January, and again in June? What change in the animal's environment causes the difference?	3	0	12	3	1
68. Water is essential to green plants.					
If one plant is watered every day and another similar plant is not watered, although they are both kept at room temperature in a light place, what difference will be seen in the two plants at the end of a week?	4	0	20	1	3
If a few bean seeds are placed in a bottle and kept dry and a few more are placed in a similar bottle and kept moist for several days while both bottles are kept at room temperature, in which bottle will the seeds germinate?	4	0	20	1	3
69. The oxygen that is free in air and water supplies the respiratory needs of living things.					
If a quart of water is boiled so that the air, and hence the oxygen, is expelled from it and then a goldfish is put into this water while another goldfish is in another container of fresh water with adequate air, does one goldfish swim at the surface of the water? If so, which one? If one does, what is it seeking that the other finds in the water?	4	0	20	3	1
If the air in a bell jar is tested with a glowing splint to determine the presence or lack of oxygen and then a small animal, such as a white rat is put into the jar for some minutes and then the air in the jar is tested again, will oxygen be found present in both cases? In only the first case? In only the second case?	4	0	17	4	0
71. The oxygen of the atmosphere is removed by animals and plants and restored by the chlorophyll-bearing plants.					
If a plant and a lighted candle are placed under a bell jar, will the candle keep burning or will it go out? If the	4	0	17	3	1

candle does not keep burning, indicating a lack of oxygen, can it be lighted again after a lapse of twenty-four hours even though the bell jar has not been opened? (The candle may be lighted, if enough oxygen is present, by an electrical device resembling a spark plug).					
72. Certain optimal conditions of temperature, moisture, and light are essential to most organisms.					
If a healthy geranium plant is kept at room temperature on a window sill, and another is kept on a hot radiator while a third is kept in a refrigerator for two weeks, which plant will be healthiest? Which plant, if any, will die?	4	0	19	3	1
If bean seeds are planted and some kept at room temperature, some are kept at a high temperature and some are kept at a low temperature, at which temperature will the most seeds sprout and most seedlings grow?	4	0	20	3	1
If bean seeds are planted in two boxes and both boxes are kept on a window sill at room temperature and the beans in one box are watered each day while those in the other receive no water, in which box will the beans sprout and the seedlings grow?	4	0	20	3	1
If one plant is kept at room temperature before a window and another similar plant is kept at the same temperature but in a dark place, which plant will be healthier after several weeks?	4	0	20	2	2
If two gelatin cultures are prepared and bacteria is placed on them by touching each with a finger and then one is kept in a light place at room temperature and the other in a dark place, on which culture will the more bacteria be evident after three days?	4	0	18	2	2
If three cultures are then prepared and each is kept in a light place but one is at room temperature, and another is kept at high temperature, and another is kept at a low temperature (refrigerated) on which culture will more bacteria be evident after three days?	4	0	18	3	1
75. Micro-organisms which cause communicable diseases often go from person to person through the air.					
If, of three prepared agar cultures, one is kept sterile, one is exposed to the cough of a person and one is exposed for two minutes in the school corridor when classes are going from room to room, what is to be observed on each culture after several days? (Cultures are covered immediately after exposures and kept covered.) What, if anything, is present on the exposed surfaces that is not on the sterile surface? If anything is there, what caused it?	4	0	19	3	1
77. The materials forming one or more substances may be changed into one or more other substances measurably different from those that were combined.					
If a mixture of iron filings and sulfur is heated in a test tube over a Bunsen burner until the mixture glows, and if it is then allowed to cool, does the material in the test tube now look, feel, or smell like either iron or sulfur? Are iron filings or is the material more readily attracted by a magnet?	4	0	18	3	1
79. A body immersed or floating in a liquid is buoyed up by a force equal to the weight of the liquid displaced.					
If a stone is suspended from a spring balance and the balance is read, and if the stone is then submerged in water in an overflow can, and the balance is again read, how much weight, apparently, has the stone lost by being submerged in the water? If the water displaced by the stone is weighed, is this weight greater than, less than, or equal to the weight apparently lost by the stone when it was submerged?	4	0	19	2	2

80. A floating body displaces its weight of the liquid in which it floats.					
Which of three blocks of wood, similar in size and shape but differing in weight, will sink most deeply into water?	4	0	18	1	3
If a small can has weights put into it so that it barely floats in an overflow can of water, how does the weight of the can and its load together compare with the weight of the water displaced?	4	0	14	2	2
If a block of wood is placed in an overflow can filled with water, what weight of water does the block displace? Is this weight greater, equal to, or less than the weight of the block?	4	0	15	2	2
81. A fluid moves from points of greater pressure to points of lower pressure.					
If a bottle is fitted with a two-hole stopper, and a glass tube is inserted through one hole so that it nearly reaches the bottom of the bottle, can water be forced from the bottle by forcing air into the bottle through the other hole in the stopper?	4	0	17	2	2
If a test tube containing only air is supported upside down in water and is then put under a bell jar, what change can be seen in the column of air in the tube, as air is withdrawn from the jar?	4	0	13	4	0
If a funnel is fitted with a rubber dam over the larger end, in which direction does the dam bulge as air is drawn from the narrow end of the funnel? as air is forced into the funnel from the narrow end?	3	1	15	3	1
If a glass tube drawn out so as to form a jet is inserted in a one hole stopper which is used to stopper one end of a lamp chimney, so that the jet is inside the chimney, what is seen as the stoppered end of the chimney is thrust into water?	4	0	13	4	0
When a model lift pump is operated, which valve opens on the up stroke and which on the down stroke?	3	1	13	3	1
Can much, little, or no water be sucked from a bottle full of water through a glass tube inserted into the bottle through a one-hole stopper that tightly closes the bottle?	3	1	13	2	2
Can water be poured more readily into a bottle through a funnel inserted in one hole of a two-hole stopper which is then used to stopper the bottle, when the other hole in the stopper is closed with a finger, or when this hole is left open?	2	2	10	3	1
If two containers of water at different levels are connected by a rubber tube which acts as a siphon, does the water flow from the higher to the lower level or from the lower to the higher?	2	2	6	3	1
82. The pressure at any point in a fluid at rest is the same in all directions.					
If three holes are made in a can at the same level and then water is poured into the can from a large container, will the water spurt a greater distance from one hole than from another, or will it spurt an equal distance from all three holes?	4	0	14	3	1
If a thistle tube, bent into a right angle near the wide end, is equipped with a rubber dam over the wide end and connected, by a rubber tube from the narrow end to a manometer, and is then thrust into water so that the wide end is immersed, what differences in pressure, if any, are observed as the tube is turned in different directions? If a straight tube, similarly equipped, is thrust to the same depth in water, will the pressure indicated be more than, less than,	4	0	11	4	0

or equal to the pressure indicated by manometer connected to the bent tube? If now a third tube bent to resemble the letter J with the wide end forming the short arm is equipped as the other two and is then thrust into water to the same depth as the other two, is the pressure indicated greater than, less than, or equal to the other pressures indicated?					
83. The quantity of energy radiated from a body increases as the temperature of the body increases.					
How close to a piece of iron, that has been heated but does not glow, can one's hand be brought without discomfort? How close, when the iron has been made red hot?	4	0	16	2	2
84. Every pure liquid has its own freezing and boiling point.					
If equal volumes of samples of water, mercury, and alcohol are put into small containers and then the containers, each with a thermometer in it, are put into a freezer (such as ice cream is kept in) and some dry ice is packed around them, at what temperature does the water freeze? If the alcohol freezes, at what temperature does it freeze? If mercury freezes, at what temperature does it freeze? Are these temperatures the same or different?	4	0	15	4	0
If samples of water and alcohol are boiled in separate beakers, at what temperature does each boil? Are these temperatures the same or different?	4	0	16	4	0
85. Under identical conditions, bodies of land heat and cool more rapidly than do bodies of water.					
If equal weights of sand and water are put into similar pans and the pans are then kept in the sunshine for an hour, which becomes warmer?	4	0	20	3	1
If one test tube half full of sand and another half full of water have been placed in boiling water for five minutes and then each has been permitted to cool for three minutes, at the end of this time which is warmer?	4	0	18	4	0
86. Sunlight is composed of several colors and may be dispersed, by a prism, into a spectrum containing these colors.					
In a darkened room, if a light is permitted to pass through a slit in a blind and then go through a prism and thence to a surface that is white in sunlight, will the surface remain white or will colors be seen? (This may be done with a slit in a card in the slide holder of a slide projector.)	4	0	17	3	1
87. Dark, rough, and unpolished surfaces absorb light and radiant heat more rapidly than do light-colored, smooth and polished surfaces.					
If two cans, one with a bright surface and the other with a dark rough surface, are filled with equal amounts of water at the same temperature, and each is covered with a small board, which do not shade the cans, and left in the sunshine for two hours, will the water in the bright or the dark can be warmer?	4	0	20	1	3
If clear water at 68 degrees F is poured into a small beaker and an equal volume of dark-colored water (water dyed with ink) at the same temperature is poured into a similar beaker and each beaker is kept 4 inches from a lighted electric lamp for thirty minutes, in which beaker will the warmer water be?	4	0	17	3	1
88. In a medium of uniform optical density, light travels in straight lines.					
If a card with a slit in it is placed one foot from a light and then a similar card is placed one foot behind that and then	4	0	12	3	1

a third card is placed one foot behind that so that the light can be seen through the three slits, is the line through the slits from the light to the eye straight or curved?					
Can a candle flame be seen through a tube that is curved, or bent, or through one that is straight?	4	0	18	2	2
If a card is held between the wall and a light, is the line made by the light, the edge of the card, and the edge of the shadow of the card, straight or curved?	4	0	12	1	3
89. The color of a translucent object is determined by the wave lengths of the light rays it transmits.					
If a blue filter is placed in a beam of light which then is passed through a prism, how does the spectrum produced differ from that produced by white light? If a red filter is used in the place of the blue, how does the spectrum compare from that produced similarly by white light?	4	0	16	4	0
90. When a ray of light strikes an object so that part of the light is reflected, the angle of incidence is equal to the angle of reflection.					
If the image of a pin in front of a vertical plane mirror is sighted from one side with a rule and a line is drawn from the point of sighting to the mirror towards the image and then a line is drawn from the point where the first line meets the mirror to the pin, what relationship is there between the angle which the line from the pin to the mirror makes with the mirror and the angle made by the sighting line and the mirror?	4	0	14	1	3
93. Some of the materials in the soil are formed through the physical disintegration of rocks.					
If various samples of soil are examined with a hand lens, which samples, if any, contain small particles of decayed rock?	4	0	17	4	0
97. With the inclined plane the weight moved times the height through which it is moved is equal to the acting force times the length of the plane provided that friction is neglected and that the force is parallel to the plane.					
How does the force required to pull a block up an inclined plane change as the slope is made steeper?	4	0	15	0	4
How does the product of the length of the plane and the force needed to pull a block up the plane compare with the product of the weight of the object and the height of the plane?	4	0	12	1	3
104. All elements found in an organism are found in its environment.					
If a potato is peeled and placed in a shallow pan and is then heated, what evidence, if any, is there that moisture is given off? If then a sample of soil such as the potato grew in is similarly heated, what evidence, if any, is there that the soil contains moisture?	3	1	12	3	1
108. Within the bodies of plants and animals, water and substances in solution pass by osmosis through membranes.					
If a piece of animal membrane is tied over the mouth of a thistle tube, the bulb is filled with a sugar solution, and the tube is supported vertically with the membrane in water for a day, will some of the solution have passed through the membrane and thus lowered the level of solution in the tube, or will water have gone through the membrane and thus raised the level of the solution, or is any	4	0	15	3	1

change seen? If the water is tasted before and again after the experiment, what change in taste, if any, is observed?					
112. The colors of certain animals serve to conceal them, to distinguish them, or to make them conspicuous in ways that aid survival.					
If, in a high school biology text book or a similar book, pictures of rabbits can be found that were taken in the fall and also some pictures that were taken in the winter, what difference, if any, can be found? If there is a change of color, what advantage does the rabbit derive from it?	3	1	16	4	0
If, in a high school textbook or some other source, pictures of wild birds and animals can be found, which birds, or animals, if any, seem to blend with their surroundings? What advantages toward survival do the animals gain from blending with their surroundings, if they do?	3	1	16	4	0
116. Disease germs may be transmitted through food and water, by contact, by biting-insects, and by carriers.					
If two cultures are prepared and a fly is allowed to walk on one and the other is kept sterile, is there any evidence, after a few days, that the fly carried bacteria on its feet?	4	0	19	2	2

JUDGMENTS AS TO WHETHER THE EXPERIMENTS CONTRIBUTE OR DO NOT CONTRIBUTE TO THE PRINCIPLES TO WHICH THEY ARE ASSIGNED

Although there were 27 cases in which a judge did not agree with the investigator that the experiment was contributory to the principle to which it was assigned, only 25 experiments were involved as in 2 cases the experiment was judged to be not contributory by 2 judges. The related data are presented in Table II.

TABLE II

NUMBERS OF EXPERIMENTS AND NUMBERS OF JUDGES WHO JUDGED THEM TO BE CONTRIBUTORY TO THEIR RESPECTIVE PRINCIPLES

	Number of Experiments	Number of Judges
	223*	4
	23	3
	2	2
Total	248	

* This line is to be read thus: Two hundred twenty-three experiments were judged to be contributory to the principle to which they were assigned by 4 evaluators.

FINDINGS CONCERNING THE RELATIVE DESIRABILITY OF THE EXPERIMENTS

Each of the four evaluators was asked to (1) indicate whether or not each experiment was contributory to the principle to which it was assigned, (2) to indicate the extent to which the experiment was desirable for inclusion in a course in general science, and (3) to indicate whether each experiment could be performed more appropriately as a demonstration or as individual laboratory experiment.

The extent to which the principle was desirable, according to criteria previously stated, in a course in general science was indicated on a 5-point scale. On this scale, a principle marked 5 by an evaluator would, in his opinion, be highly desirable in such a course; one marked 1 would similarly be undesirable in such a course. The collective opinion of the four judges is expressed as the total of the marks assigned to each experiment by them. To illustrate, an experiment considered highly desirable by all four judges would receive a total mark of 20; one considered undesirable by all would receive a total mark of 4. It was found, however, that no experiment received a total mark as low as 5.

The data concerning the marks assigned to the experiments by the evaluators are presented in Table III.

TABLE III

NUMBERS OF EXPERIMENTS TO WHICH THE EVALUATORS ASSIGNED THE TOTAL MARKS INDICATED

Number of experiments	Marks Assigned
17 *	20
24	19
27	18
30	17
31	16
31	15
19	14
29	13
14	12
10	11
9	10
3	9
1	8
1	7
2	6
0	5
Total 248	

* This table is read thus: 17 experiments were considered highly desirable by four evaluators and hence each received a total mark of 20.

FINDINGS CONCERNING THE DEMONSTRATION AND THE INDIVIDUAL LABORATORY METHODS OF PERFORMING EXPERIMENTS

Each of the evaluators indicated whether, in his opinion, each experiment would be done more appropriately as a demonstration or as an individual laboratory experiment.

The evaluators' judgments on this question are presented in Table IV.

TABLE IV

NUMBERS OF EXPERIMENTS THAT WERE DESIGNATED BY THE INDICATED NUMBERS OF JUDGES AS BEING MORE APPROPRIATELY PERFORMED AS DEMONSTRATIONS OR AS INDIVIDUAL LABORATORY EXPERIMENTS

Experiments Number	Experiments Percent	Numbers of judges who indicated experiments to be demonstrated	Numbers of judges who indicated experiments to be performed as individual laboratory experiments
* 71	29	4	0
93	37	3	1
48	19	2	2
29	12	1	3
7	3	0	4
248	100		

* This table is read thus: Seventy-one, or 29 percent, of the 248 experiments were judged by four evaluators to be more appropriately performed as demonstrations than as individual laboratory experiments; and by no judges to be more appropriately performed as individual laboratory experiments than as demonstrations.

CONCLUSIONS

From this investigation, if it is granted that the techniques and the findings secured are acceptable, the following conclusions seem justified.

1. The large number of experiments which were judged to be suitable for use with the inductive method indicates the appropriateness of this method in the teaching of general science.

2. The experiments approved by the judges were deemed by them suitable for performance with simple apparatus. This judgment emphasizes the practicability of teaching an acceptable laboratory course in general science in schools possessing only meagre equipment.

3. The fact that 71, or 29 per cent of the experiments were judged as suitable for performance as demonstrations by all evaluators emphasizes the importance of demonstration in a general science course.

4. One hundred seventy-seven, or 71 per cent, of the experiments were judged by at least one judge to be appropriate for performance as individual laboratory experiments. This fact lends support to the contention [5] that not only is the individual laboratory method appropriate for use in general science courses, but also that it is worthy of much wider use than is customarily made of it.

RECOMMENDATIONS

1. It was found that many good experiments do not lead directly to principles of science. These experiments might, in considerable number, prove suitable for teach-

[5] *Science Education in American Schools*, Forty-sixth Yearbook, N.S.S.E. Part 1. Chicago: Distributed by the University of Chicago Press, 1947. p. 160.

ing the elements of scientific method and attitude. Studies to determine the extent to which these materials are contributory to desirable objectives other than the development of understandings of principles would constitute valuable contributions to the teaching of science.

2. The importance of the inductive method of teaching science justifies the additional analysis of materials for the purpose of discovering experiments suitable for performance by this method. Such materials would include children's books, magazines, and, perhaps, even comics.

REVIEW OF THE GENERAL GOALS IN SCIENCE TEACHING

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I. Aims or Objectives Proposed by National Committees

The first extensive study dealing with science education in the secondary schools was made in 1920 by the Science Committee of the Commission on Reorganization of Secondary Education.[1] The report, among other things, attempted to show how science instruction could contribute to the attainment of the seven cardinal principles or objectives of secondary education as set forth by the Commission. The Commission [2] recommended the following seven objectives for the curriculum in the high school:

1. Health
2. Command of fundamental processes
3. Worthy home membership
4. Vocation
5. Civic education
6. Worthy use of leisure
7. Ethical character

This report of the Science Committee attempted to show how science could contribute to the large social objectives listed above. Science was considered of special value, and was to contribute to all principles except the second.

In 1927, a special committee of the American Association for the Advancement of Science submitted a report at the Nashville meeting on the place of science in education.[3] The chief addition which this report made to the list of cardinal principles was the recommendation that the scientific method in science be included as a major objective of science teaching.

Of greater significance was the Thirty-First Yearbook of the National Society for the Study of Education published in 1932.[4] This yearbook, for the first time, offered a comprehensive program of science teaching and advocated the definite organization of science instruction in all grades from I through XII. The committee defined the aim of education as, "Life Enrichment through Participation in a Democratic Social Order," [5] and built its program around

[1] Otis W. Caldwell and Others, *Reorganization of Science in Secondary Schools* (United States Bureau of Education, Washington, D. C.: Government Printing Office, Bulletin No. 26, 1920).

[2] "The Commission on the reorganization of Secondary Education," (United States Bureau of Education, *Cardinal Principles of Education*, Washington, D. C.: Government Printing Office, Bulletin No. 35, 1918).

[3] American Association for the Advancement of Science, "Committee Report on the Place of Science in Education," *School Science and Mathematics*, 28:640–64, June, 1928.

[4] S. R. Powers and Others, "Program for Teaching Science," *Thirty-First Yearbook of the National Society for the Study of Education*, Part I (Bloomington, Illinois: Public School Publishing Company, 1932).

[5] *Ibid.*, p. 42.

a number of selected scientific principles or generalizations instead of aims or objectives. The main purposes of science for the junior high school are stated as follows:

> The Committee recognizes two important functions in the course in science for Grades VII, VIII, and IX: first, to give such a background of learning that will enable the pupil to adjust himself intelligently to the phenomena of experience; second, to furnish an introduction to the major fields of science, to the end that the pupil may become so well acquainted with these fields that he will be able, with some assurance, to determine in which branch or branches he may later desire to do more specialized work.[6]

In 1938, a comprehensive statement of the very broad social purposes of science in general education in the secondary school was published by the Progressive Education Association.[7] This report attempted to describe the aims of education in a Democracy, and the relation of science education to these objectives. It attempted to orient science teaching toward broad areas of living such as personal living, personal-social relationships, social-civic relationships, economic relationships, and the disposition to use reflective thinking in the solution of problems. The report did not formulate a program of science, but through its philosophy attempted to indicate various ways in which science might become functional for the pupils to whom it was being taught. With the exception of promulgating the scientific method as an objective of science teaching, it is difficult to see what bearing most of the chapters in this report have to do with the teaching of science.

The American Council of Science Teachers[8] prepared a report in 1942, dealing with the philosophy for science teaching as formlated by a representative committee of science teachers. This report presented a point of view for science teaching which was very similar to the above report of the Progressive Education Association. It added the areas of safety, consumer education, and conservation to the previous objectives of science teaching.

The most recent report of this type under review is the Forty-Sixth Yearbook of the National Society for the Study of Education.[9] This report proposed eight functional objectives of science teaching:

1. Functional information or facts
2. Functional concepts
3. Functional understanding of principles
4. Instrumental skills
5. Problem-solving skills
6. Attitudes
7. Appreciations
8. Interests

It is interesting to note that the committee preparing this report attempted to set forth rather specific objectives attainable in the classroom as contrasted with very general objectives enumerated in a number of previous reports. The chief contribution of this report was the viewpoint of the committee in stating, "that the objectives are conceived as *directions of growth,* and that learning outcomes in science education, whatever their type, shall *function* in changed behavior." [10]

II. Aims or Objectives Proposed in Science Education Books.

Downing [11] writes that the science teacher must always bear in mind the following three objectives:

1. The acquisition by the pupils of those skills that are based upon the most important scientific knowledge.

[6] *Ibid.*, pp. 127–28.

[7] Progressive Education Association, *Science in General Education* (New York: D. Appleton-Century Company, 1938).

[8] American Council of Science Teachers, *Science Teaching for Better Living* (Washington, D. C.: National Committee on Science Teaching, National Educational Association, 1942).

[9] V. H. Noll and Others, "Science Education in American Schools," *Forty-Sixth Yearbook of the National Society for the Study of Education,* Part I (Chicago: University of Chicago Press, 1947).

[10] *Ibid.*, p. 26.

[11] E. R. Downing, *An Introduction to the Teaching of Science* (Chicago: University of Chicago Press, 1934), p. 7.

2. The development in pupils of skill in scientific thinking.

3. The establishment in the pupils of those major emotionalized standards inclusive of the multitudinous lesser desires, dispositions, and attitudes that serve as the motives for the many daily acts that involve science.

Preston[12] defines the objectives of science teaching as follows:

1. Developing fundamental attitudes towards life and human environment.

2. Developing the abilities and special skills needed to effectively learn good study habits and intelligent thinking.

3. Developing the scientific attitude in the search for knowledge and the making of decisions.

4. Developing a desire to continue the study of science because deep interests have been aroused.

Croxton[13] presents the following five statements as the aims of science education:

1. To cultivate scientific attitudes and methods of procedure.

2. To lead to broader concepts, generalizations, and outlooks.

3. To open new avenues of interest and satisfaction.

4. To enable the individual to meet the problems of existence with the available scientific knowledge and requisite skills.

5. To develop social attitudes and aprecations.

Noll[14] analyzed 130 different sources for aims of science education. He lists the following as the major objectives of science teaching:

1. Understanding and appreciating the nature and organization of the environment.

2. Attainment of health by learning habits of healthful living.

3. Acquisition of desirable habits of work and study.

4. Inculcation in the use of the scientific method and attitude.

5. Development of ability to do household tasks involving scientific applications.

6. Development of an interest in science and scientific hobbies.

7. Exploring the field of science to become acquainted with the scientific areas.

8. Providing for a basis of vocational education.

Heiss, Obourn, and Hoffman[15] give the following as the main outcomes of science teaching:

1. A fund of interpretive understandings.
2. A fund of appreciations.
3. A group of attitudes and mind-sets.
4. A method of attack on problems.

III. Aims or Objectives found in General Science Courses of Study.

The Colorado State Department of Education[16] presents the following lists of objectives for science education:

1. To develop an appreciation of the natural and physical environment in which children live.

2. To develop an appreciation of the part which science plays in children's lives.

3. To develop a scientific method of thinking and attitudes of problem solving.

4. To develop desirable social attitudes in regard to conservation, health, safety, and sex.

5. To develop scientific skills and abilities.

6. To widen interests and enrich children's experiences.

7. To help children acquire those science concepts which are necessary to the understanding of scientific principles.

[12] C. E. Preston, *The High School Science Teacher and his Work* (New York: McGraw-Hill Book Company, 1936), pp. 51–55.

[13] W. C. Croxton, *Science in the Elementary School* (New York: McGraw-Hill Book Company, 1937), p. 38.

[14] V. H. Noll, *The Teaching of Science in Elementary and Secondary Schools* (New York: Longmans, Green, and Company, 1939), pp. 13–14.

[15] E. D. Heiss, E. S. Obourn, and C. W. Hoffman, *Modern Methods and Materials for Teaching Science* (New York: The Macmillan Company, 1940), p. 9.

[16] *Course of Study for Elementary Schools*, State of Colorado (Denver, Colorado: Department of Education, 1942), p. 275.

The California State Department of Education[17] adds the following general aims for science education:

1. To prepare the individual to live healthfully, successfully, and responsibly in a changing world.

2. To gain the maximum of satisfaction and ennoblement from the understanding and appreciation of his world.

3. To react intelligently in a continously adaptive way to the succession of environmental influences and events that shape the course of his life, making the most of the opportunities presented to him, and reducing to a minimum the undesirable consequences of the misfortunes that befall him.

The Cincinnati Public Schools[18] list the following five objectives of science teaching in the junior high school:

1. To gain an understanding of the laws of nature operating in his environment.

2. To develop a scientific attitude of mind and a better understanding of how to use the scientific method.

3. To develop new concepts and clarifications in science.

4. To orient himself to specialized sciences taught in high school.

5. To apply concepts to new situations.

In a recent publication the Louisville Public Schools[19] list the following as the main objectives of science teaching:

1. To direct children towards the importance of making their own thinking reliable.

2. To guide children to a better understanding of the world in which they live.

3. To develop in children habits and understandings necessary for good physical, mental, and emotional health.

4. To help children discover and develop new interests for leisure time activities.

IV. Aims or Objectives Listed in Current Literature.

Hunter and Spore[20] made a comprehensive survey of 2200 schools in the United States asking teachers to rank thirty objectives in science teaching. On the basis of 250 returns from junior high schools the following ten objectives are given as the ones which ranked at the top:

1. To develop a better understanding of the environment.

2. To impart knowledge of the environment.

3. To develop an appreciation of the environment.

4. To promote a better understanding of personal health needs.

5. To help develop the power of observation.

6. To help students acquire worthwhile ideals and habits.

7. To help develop attitudes of freedom from dogma and superstition.

8. To promote good citizenship by applying knowledge of science.

9. To aid students in solving life problems.

10. To attempt to train students in steps of scientific method.

Powers[21] proposes the following outcomes of science education to meet the needs of youth in the postwar world:

1. Good health and physical fitness.

2. Work experience.

3. Comprehension of the natural resources of the nation.

4. Comprehension of the impact of science and technology on our society.

5. Ability to select and use materials made available by science in solving social problems.

[17] *Science in the Elementary School,* State of California (Sacramento, California: Department of Education, 1945), p. 12.

[18] *The Seventh-Eighth Grade Manual,* Cincinnati Public Schools (Cincinnati, Ohio: Curriculum Bulletin No. 200, 1947), p. 159.

[19] *Science Experinces for Elementary School Children,* Louisville Public Schools (Louisville, Kentucky: Curriculum Bulletin No. 11, Part II, Vol. 1, 1949), pp. 1–3.

[20] G. W. Hunter and L. Spore, "The Objectives of Science in the Secondary Schools of the United States", *School Science and Mathematics,* 43:633–47, October, 1943.

[21] S. R. Powers, "The Goals of Education in Science," *Science Education,* 23:136–41, April, 1944.

6. Consumer education.

In a later publication Powers relates his goals of science teaching to general education by stating his philosophy as follows:

> The goal of science teaching in general education is to help young people to make science as much a part of their lives as it is of the society in which they grow up, work, raise their families, and play their parts as citizens.[22]

In this same article he lists the goals of science teaching in general education as follows:

1. Understanding of the world and man and competence to use this understanding to correct the inconsistencies and naive notions that become obvious in the thinking of young people as they mature, and to use these understandings in their reflection about values.

2. Understanding of the processes and potentialities of technology, and competence to use this understanding in directing the utilization of resources.

3. Competence in using the elements of scientific method that have general application in dealing with personal and social problems.

4. Comprehension of the effects of infiltration of ideas and concepts, scientific in their origin, upon man's conception of good and bad.

Hunter and Ahrens [23] report the results of a questionnaire sent to 1200 science teachers in junior and senior high schools in California. Objectives were grouped under classifications which dealt with scientific method; those which were functional; and those which were classed as miscellaneous. The findings were compared with a similar study made in 1940. The general trend shown was that science teachers in both junior and senior high schools were shifting their emphasis on objectives away from the strictly functional objectives in favor of those dealing with scientific method and factual knowledge.

In summing up the thoughts expressed in the numerous objectives and the diversity of aims found in the various sources studied, the following quotation from the Forty-Sixth Yearbook of the National Society of Education seems most appropriate:

> Science is today on a plane of high significance and importance. It is no longer, if indeed it ever was, a mysterious and occult hocus pocus to be known only to a select few. It touches, influences, and molds the lives of every living thing. Science teachers have a great opportunity and responsibility to make a large contribution to the welfare and advancement of humanity. The intellectual aspects of this responsibility are at least coequal in importance with the material. Science is a great social force as well as a method of investigation. The understanding and acceptance of these facts and this point of view and their implementation in practice will, more than anything else, make science teaching what it can and should be.[24]

V. Establishment of the Major Objectives.

It was felt that to have a logical starting place for conducting a science interest survey, a clear statement of the aims and objectives for teaching science was the first step. An analysis of the comprehensive listing of aims and objectives in science education in the preceding sections furnished the basis for the synthesis of the five major goals and the subdivisions within each goal which are given below. An attempt was made to include all significant contributions from the various sources cited, and to combine the thoughts in as many cases as possible to keep the list from becoming too extensive.

A. To Develop Understanding and Insight into the Forces and Nature of the Environment.

1. Organization of the environment
2. Existence in the environment
3. Appreciation of the environment
4. Natural laws of the environment

[22] S. R. Powers, "Science and General Education," *Teachers College Record,* 49:373–81, March, 1948.

[23] G. W. Hunter and H. J. E. Ahrens, "The Present Status of Science Objectives in the Secondary Schools of California," *Science Education,* 31:287–95, December, 1947.

[24] *Forty-Sixth Yearbook, op. cit.,* p. 39.

B. To Develop Knowledge and Understanding of the Facts, Principles, and Concepts of Science.

1. Understanding common facts of science
2. Understanding general principles of science
3. Gaining new concepts of science
4. Applying the principles of science in the home

C. To Develop Personal Growth in the Habits and Methods of Science.

1. Ability to use the scientific method in problem solving
2. Understanding of personal health needs
3. Developing scientific skills and work experience
4. Gaining freedom from superstitious beliefs

D. To Develop Interests and Appreciations in the Benefits of Science.

1. Enlarging upon scientific interests
2. Discovering new avenues for study
3. Gaining new meanings in the contributions of science
4. Desiring further knowledge in science

E. To Develop Democratic Social Attitudes towards the Resources of Science.

1. Understanding the impact of technology on society
2. Seeing developments in science as a solution to social problems
3. Understanding the importance of natural resources to man
4. Discovering consumer education as a scientific process.

THE PICTURE OF CANCER AS PAINTED BY THE GENETICIST

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I. INTRODUCTION:

THE picture of cancer is not a beautiful work of nature's art. Rather, it is ugly, colored with fear, dread, and uncertainty. It is a picture of growth in living things gone berserk; cell growth completely and permanently out of control.

"Cancer belongs to that class of common diseases, the fight against which is the fight for longevity itself." [1a] Among human beings it is probably the most feared disease. Next to heart disorders it is the cause of more deaths of people in all age groups. Certainly, it is the most mysterious malady of our day and has challenged more scientific research than any other one disease.

The word cancer comes from the Latin word for crab. Just what prompted the association of the two words is a bit doubtful. The word cancer is an inclusive term covering such medical terms as carcinoma, and malignant tumors or sarcoma. It refers to any persisting and malignant (destructive) growth originating in the epithelial tissues or glands which develop as ingrowths of these (carcinoma), or to malignant tumors developing from connective tissue (sarcoma). "In cancer the cells show abnormal nuclei and atypical mitotic figures" [1b] and show unusually rapid multiplication.

Examination of cancer tissue under the microscope shows the close association between cancer and the "organization of the cell".[1c] This, plus the fact that, unlike any other disease, cancer appears under the same form in almost all animal species and even in plants, suggests the "impairment of some mechanism essential to life".[1d] If the body cannot regain balance in cell growth,

after periods of unbalance due to age cycles or exceptional or abnormal conditions, uncontrolled growth gets completely out of hand. The center of this growth produces an increased mass of tissue called a neoplasm. Many such centers remain completely out of control and thus become malignant neoplasms, or cancer.

The origin of cancer is not fully known. However, it is certain in many cases that there are two sets of factors at play; natural susceptibility and some inciting environmental agent (X-ray, tar, soot, lubricating oils, various coal tar products, etc.).

The strange thing about cancer is that the more that is known about it, the more experiments carried out with it, the more illusive becomes the real underlying cause. A complete, adequate, and satisfying answer to the riddle of cancer seems further from the grasp of scientists now than when it first challenged the imagination of the interested researcher. Knowledge and experimental evidence, instead of clearing up the matter and painting the picture in more vivid colors, have shrouded the whole in a denser fog. Rather clear cut results to individual experiments lead only to a maze of conclusions when put together with other results.

What part does heredity play in all this? That is the only question considered here. And that is the only question for which an answer will be sought in this treatise on cancer.

II. OF MICE:

Any hereditary consideration of cancer should include a review of some of the more important experiments carried out with mice. One cannot say, of course, such and such a thing happens in mice, therefore, the same thing will happen in men, but, since "heredity is one of the most general concepts in the entire domain of Biology",[2a] it seems justifiable to believe that the laws applicable to the mouse, rabbit, or any other experimental animal will hold good for man, too. This seems doubly justified because cancerous growths are "so similar no matter in what species they arise". Virtually every type of carcinoma, sarcoma, or malignant tumor has been studied in mice. Many have been produced artificially, most are spontaneous. At any rate, experimentation holds the answer to the final proof of any scientific problem genetics included, and since it is impossible to experiment with humans in this field of science research (obvious for many reasons) another animal must be substituted, and mice have proved to be very satisfactory in this respect.

One of the early workers along this line was Maude Slye, who, over a period of thirteen years studied at least 5,000 spontaneous tumors in about 40,000 mice; performed about 200,000 autopsies, and saw virtually all the tumors encountered in human subjects. "She found that not only the incidence of cancer, but also the type and location are influenced by heredity. Her studies unquestionably demonstrate a marked inheritability of resistance to cancer."[2b] She thought at first, and quite naturally too, that these two capacities of resistance and susceptibility are transmitted as unit characters, because, in crosses between non-cancerous strains and cancerous strains which she was able to develop, she found the non-cancerous condition dominant. In offspring from crosses among these heterozygotes (carrying two different factors for the same characteristic, one dominant over the other), the usual 25% of recessives reappeared in a manner similar to a simple Mendelian pair of characters.

This type of work requires infinite patience and is especially difficult because cancer does not show itself until later in life as a general rule. "Not until after death and both parents autopsied can the fate of their descendants be settled"[2c] and selection made. It is in this manner of selection that resistant strains are produced through breeding by "eliminating the weaknesses upon which the disease might lay hold".[2d] Also, by the use of selection, other strains

may be produced in which every offspring will die of cancer.

Further experiments by Little, Strong, Cloudman, Spangler, and many others verified and strengthened the belief that cancer susceptibility and inheritance were closely related but also proved the early conclusions to be false in that cancer susceptibility inheritance is not the simple recessive character Slye first thought to be true, before the necessity of dealing with highly inbred homozygous strains was realized. Even she was willing in 1937, after further work, to admit the single factor explanation to be inadequate. At this time she offered a two-part hypothesis; (1) "a recessive factor for each type of malignancy (carcinoma, sarcoma, leukemia)",[2e] (2) "another recessive factor for each site of malignancy in the animal".

An interesting angle to the picture developed from experiments with a particular kind of cancer, namely mammary tumors. A new direction was pointed by Fekete and Green in 1936 when they discovered that blocking the nipples tended to produce mammary tumors in cancer-susceptible strains but not in non-cancerous strains. About the same time Pybus and Miller, working with the same type of tumor, concluded from experimentation with crosses, through several years of inbreeding between female cancerous strains and male non-cancerous strains, and visa-versa, that "the tendency to mammary cancer can be inherited through the male, probably as a recessive" [2f] but which showed a decided preference for females. Leo Loeb has shown that this same type of cancer is not only associated with a hereditary factor but that follicular hormone (Snyder believes that all hormones owe their presence each to a particular gene. Genes are found in the chromosomes which are in the nuclei of the cells. They carry or control the characteristics that are inherited.) is also required, because removal of the ovaries of cancer-strain females a day or so after birth "prevents the appearance of cancer later in life".[2g] And, conversely, the injection of the follicular hormone in the males results in the development of mammary tumors, a condition which does not occur normally, even in males of the cancerous strains. Similar results of work by Bittner and Little have been labeled the "extra-chromosomal" or "maternal-influence" [2h] theory.

These, and other experiments, were the stepping stones to the so-called "milk influence" theory, a term devised by Bittner as an explanation to some of his genetic results with mammary tumors in mice. He obtained new and quite revolutionary results by feeding new-born offspring of cancerous-strain mice on the milk of a foster mother belonging to the cancerous strain. Surprisingly enough the incidence of mammary tumors in these offspring increased from 0 to 70%. In similar manner a decrease from 100 to 50% in cancer incidence was noted in opposite cases, that is, where offspring of cancerous strains were fed on the milk of mothers of non-cancerous strains. This would seem as if the milk itself were responsible for transmitting the causal agent, but this is probably not so as both Bittner and Little suggest. There are some who lean very strongly toward the virus idea, Oberling for one. Most recent research (1949) seems to be bearing this out.[2j]

The extra-chromosomal theory previously mentioned does not explain the inheritance involved in lung carcinoma, the susceptibility of which seems to be transmitted by maternal or paternal parent of high lung tumor stock in accordance with genetic principles, probably one or more dominant factors involved.[2k] Heston, in 1941 and 1942, went so far as to say that he had found "2 factors on different chromosomes of the mouse which affect its susceptibility to lung tumor".[2l]

An interesting side light is the possible connection between pigment inheritance and that of cancer. It seems that "a mouse melanoma", (abnormal pigmentary depos-

its in a tumor) "which grows in the original strain in which it appeared, will not grow in albinos",[2m] according to conclusions drawn from experiments carried out by Spangler, Murray, and Little in 1942. This seemed to indicate "a single Mendellian gene for tumor".[2n]

Now, how do all these facts stack up? Do these experiments prove anything important? Does the geneticist have any right to claim that a connection between cancer and inheritance exists? The answer seems quite obvious, an emphatic "Yes"; at any rate, in mice. The very fact that strains, both cancerous and non-cancerous, can be produced from a spontaneous origin proves conclusively that heredity enters very definitely into the picture. And the fact that a cancer cannot be originated artificially from transplants or from the use of irritants, such as radiations (usually X-ray), coal tar products, etc., unless the heredity of the strain of animals is favorable (cancer susceptibility), further cements this proof. Of course, the exact manner of this inheritance is not clear cut, one will have to admit, nor will one explanation do for all types of cancer. There will have to be many more years of research, with many thousands of mice sacrificed for the cause, before the truth of cancer inheritance, locked within the cell itself, finally comes to light.

III. OF MEN:

Is there any other way to seek an answer to the mystery of cancer inheritance in humans except through experimentation with mice? Most assuredly. There are the family histories to examine. Naturally it takes many hundreds to give any valid conclusions and these are not always easy to obtain, nor can one be too sure of the accuracy of such reports. However, enough really thorough studies have been made and subsequent statistics compiled to make a study of them worth while.

Again we are faced with the complexity of the picture because there are so many different types and locations where malignant growths are concerned. To make it more systematic it might be better to consider the research workers, the more common types of cancer that have been studied by them, and what conclusions have been drawn, if any, concerning modes of inheritance.

The most important statistical study of human cancer, up until recent years, "was made by Waaler in Norway using 6,000 cases collected in 21 years by the Norwegian Cancer Committee".[3a] The results of this, published in 1931, show that in families where one parent had cancer, 40.7% of the male and 53.8% of the female siblings had it also; while in families where both parents were without cancer, 21.7% males and 23.1% females were the corresponding values. As regards location of the cancerous area it was found that, of the women who died of cancer of the breast, 44.7% of the cancerous siblings also had cancer of the breast, but if cancer was in some other organ only 16.5% of the siblings showed cancer of the breast. No such relation was found among males with cancer of the lip. In explaining these results Waaler offers the following hypothesis: there are "two independent factors, probably recessive, tending to produce cancer, one equally active in men and women, the other more active in women. But cancer in men could occur without these factors".[3b]

Three years previous to this, Warthin (University of Michigan Hospital) had suggested the same two-fold idea of site and susceptibility. But he thought four heredity factors were involved: two for general susceptibility and resistance, and two for organ susceptibility and resistance. He considered environment to be "more or less potent".[3c] He also believed in the strain idea for human families similar to that produced experimentally in mice; such as, mostly cancer of the stomach and intestines in one family, thyroid only in another, breast, uterus, or lip only in still others. He further thought that cancer susceptibil-

ity may be dominant in some families, recessive in others, and may also be conditioned, at least in the case of mammary cancer, by the presence of a virus. Warthin found in these so-called cancer families a tendency for it to appear at an earlier age than in the forbears and that it was usually more malignant. He firmly believes that heredity is a factor in the predisposition to cancer.

Let us examine further studies by:

(1). Pearl—sites one pedigree that includes 8 cancerous individuals in 3 generations which is 200 times as frequent as in the general population.

(2). Strong—of the Cancer Institute in Amsterdam discovered cancer in each generation for 6 generations in 1 family. Of 258 breast cancer patients, 76 had close relatives afflicted with cancer and 30 of these in the breast.

(3). Levin—(Eugenics Record Office of the Carnegie Institute) found evidence to support his contention that resistance to cancer behaves as a Mendellian dominant character and that susceptibility is the result of the absence of such resistance.[3d]

(4). Loeb—believes that there are one or more inheritable factors which predispose toward development of cancer. "In a mixed population where there is much crossing of family strains this tendency is probably equalized".[3e]

(5). Snyder—points out that various hypotheses of the inheritance to cancer susceptibility have been offered, running the gamut of dominant, recessive, multiple factors, and modifying factors. "Trauma or irritation may bring out the effect in susceptible persons earlier than hereditary factors, but intrinsic factors alone are probably sufficient if given time." [3f]

(6). Little—believes the inheritance of one or more tendencies to form cancer may be operating all around us but, because of the complexity of the biological nature of the human race and its mixed ancestry, the importance of heredity as a force in cancer control is scattered and unpredictable.[3g]

(7). Dodd (London, 1933)—reports exceptional susceptibility shown in a cancer family in which 4 different types were involved with 9 cases in 2 generations.[3h]

(8). Carnot—sites a family in which father and son had stomach cancer, the son's wife died of cancer of the breast and his 6 children and 1 grandchild also died of various forms, hardly a case of pure chance.

(9). Taylor (University of Pennsylvania)—found no correlation between cancer of the cervix and heredity.

(10). Madge Macklin (University of Ohio)—found, however, pronounced correlation between heredity and cancer of the breast. There was ten times as much cancer of the breast in families of patients with this disease as in families of patients without cancer of the breast.

The latter two studies are the most recent and, according to Dr. Snyder, have been very thorough. They were carried out scientifically in many hundreds of cases, each with a control case.

Before reviewing the facts of human inheritance thus far stated let us examine some particular kinds of diseases which are known to be cancerous and about which more specific facts may be mentioned.

(1). Breast carcinoma—There is a family described by Wood and Darling (1943) in which 7 cases (1 male, 6 females) of bilateral breast cancer, as well as 1 of the cervix, 2 of the colon, and 1 glioma of the brain occur in 4 generations. The strange part about the breast cancer is that it only developed in those who had been nursed by an affected mother. One daughter, who was not nursed by her mother (who had the disease), was free herself but her 3 daughters were affected. Thus we see "some evidence of a condition like the Bittner factor in mice".[3i]

This is reiterated by Oberling who thinks a relationship exists between hormones and mammary cancer in humans, as it does in mice. He says that what is "hereditarily transmitted is not cancer of the mamma

but an abnormal sensitivity of the mammary epithelium to follicular hormone".[3j]

(2). Xeroderma Pigmentosum (a hereditary abnormality meaning pigmented dry skin.) It is a striking example of a condition which requires for its expression the "cooperation of a gene with an environmental factor",[3k] in this case, light. Numerous pedigrees show it to be due to a single recessive gene.

(3). Von Recklinghausen's Disease (Neurofibromatosis)—This is a kind of tumor and also a defect of the nervous system. Harbitz describes a family in which it appears as a mutation. Frets, in his work, "makes a probable suggestion that a second gene is involved, perhaps a modifier or inhibitor".[3l] Cockayné studied and tabulated 111 families in which it was "strictly dominant".

(4). Glioma retinae (Retinoblastoma)—is a tumor of the retina which may develop in one eye or both; usually appearing in infants or children, rarely in persons of marriageable age. It is a specific inherited cancer disease. After reviewing the many case histories studied by Snell, Griffith, Keller, and Tonkin, Hemmes, Bell, Clausen, Waardenburg, and Weller it may be concluded that the disease is "generally inherited as a dominant, frequently but not always of low penetrance".[3m] Many of the sporadic cases may be dominant mutations.

Lenz has studied 30 families in which this kind of tumor appears and he believes it is inherited as a recessive.

(5). Stomach Cancer—This is the most common type of malignant tumor and its tendency to afflict certain families has long been noted. One historical example is the Bonapart family in which Napoleon I, three brothers and sisters, and the father all died (supposedly) of it.

Lenz believes that stomach cancer develops by preference on the soil of an old gastric ulcer and that in part, therefore, the hereditary predisposition is identical with that of gastric ulcers which he thinks is inherited as a recessive.

The most convincing proof of inheritance as an important factor in cancer lies in the many cases reported of carcinoma in identical twins. One of the most dramatic of these is the case of the 20-year old man who received an injury in the right testis, developed cancer in that area, presumably as a direct result of the blow, and died within a few years. Ten years later his twin brother, without any injury, developed cancer in the right testis. "Apparently both boys had inherited a tendency for cancer of the testis, but the onset had been hastened in one, due to the injury." [3p]

The studies of Versluys do not agree with most of the findings concerning cancer in identical twins, however. He found "concordance in little more than 30% of his cases; the other 70% had discordant neoplasms, a tumor in one twin and not in the other, or different types in different sites".[3q] This shows he seems to think, the great importance of environmental influences, something that cannot be controlled in man as it can in mice kept in the laboratory.

Madge Macklin, on the other hand, studied 62 pairs of monozygous and 43 pairs of dizygous twins in which she found a much higher frequency of tumors in the monozygous pairs than in the dizygous twins.[3r] The same relative frequency existed in type of tumor and in the organ affected. The age of onset was more nearly identical also. These findings emphasize the fact that heredity plays an important role in tumor production and the age of onset.

To all the dearth of statistical facts, of which the above make up only a sample, it is not possible to make a brief summary and then say, "Therefore, cancer is an inherited disease and its manner of inheritance is in such and such a way". No simple explanation is possible because there are too many different expressions to this mysterious and dread disease, each expression with many possible causes, of which inheritance seems, at the present time, to be

only one and that, in a more or less indirect, rather obscure manner. Just as with bacterial diseases the causes are twofold, one, predisposing, the other, activating. In the case of cancer there is little doubt that heredity is one of the predisposing causes.[3s]

No one seems to question the inheritance of a susceptibility or non-susceptibility to one or more forms of cancer. But it is difficult to find any two workers who agree on the exact form of such an inheritance, or any two types of cancer the inheritance of which may be explained in exactly the same manner.

There are now three main types of modern theory that appear to have a part in explaining the origin and inheritance of cancer:[3t]

(1). Somatic cell mutation—which is due either to nuclear, that is *genic,* or to cytoplasmic change, bringing about very rapid division of the cell.

(2). Virus—a substance, possibly an altered protein that can arise in various ways, present in the cells of a *susceptible* tissue, which leads to the development of cancerous growth.

(3). Carcinogenic substances—such as soot, tar, certain irritants from smoking, strong sunlight or more penetrating radiations (X-rays); the *inheritance* element here again being differences in susceptibility.

After all is said and done, it is not cancer itself that is transmitted but, unquestionably, some kind of cancer factor or factors.

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BOOK REVIEWS

MORGAN, ALFRED. *A First Electrical Book for Boys.* New York: Charles Scribner's Sons, 1951. 263 p. $3.00.

The author of *A First Electrical Book for Boys* has been for a long time one of America's best science writers for juveniles. Among his writings are: *Things a Boy Can Do with Electricity, An Aquarium Book for Boys and Girls, The Boys' Book of Engines, Motor and Turbines, A Pet Book for Boys and Girls,* and *First Chemistry Book for Boys and Girls.* The present title is a revised edition of a book that has proved most popular. The book gives boys and girls of junior and senior high school age a fundamental understanding of magnetism and electricity and the ways they operate. The explanations are clear and practical, accompanied by numerous drawings and illustrations by the author.

This is an excellent book for the science shelf of the high school library, for boys and girls of junior high and senior high school age, for elementary science, general science, and physics teachers.

HOGG, JOHN C., CROSS, JUDSON B., LITTLE, ELBERT P., ALLEY, OTIS E., AND NAVEZ, ALBERT E. *Physical Sciences for High Schools.* New York: D. Van Nostrand Company, Inc., 1951. 531 p.

In recent years there has been a definite trend toward offering physical science courses in high school in addition to, or in place of, the usual chemistry and physics courses. Only recently has there been published textbooks that satisfactorily meet this demand. Here is a textbook that will do much in supplying the demand for such a high school text. This book is well written, well illustrated, and has study and teaching aids that should add much to its teachability. These include suggested demonstrations, projects, questions, suggestions for further reading, things to remember, and general review questions.

Combustion has been used as the unifying theme and is built around the following units: The Nature of Things, The Earth, Temperature and Heat, Weather, Fire and Fuels, Power from Combustion, Electricity, Light, Communication, Structural Materials, and The Universe.

Mr. Hogg and Mr. Cross are science teachers at The Phillips Exeter Academy, Exeter, New Hampshire; Mr. Little formerly taught in the same school but is now physicist with the United States Air Force; Mr. Alley teaches science in the Winchester, Massachusetts, High School; and Mr. Navez teaches science in the Newton High School and Junior College, Newtonville, Massachusetts.

BLACKWOOD, OSWALD H., HERRON, WILMER B., AND KELLY, WILLIAM C. *Workbook and Laboratory Manual to Accompany High School Physics.* Boston: Ginn and Company, 1951. 278 p. $1.40.

This is a laboratory manual to accompany *High School Physics* by the same authors, reviewed below. There are 42 exercises divided into the same units as in the text. There is stated for each experiment: object, apparatus, procedure, data and calculations, and discussion of data. The manual is largely fill-in blank type.

A separately bound series of tests covering each unit is available to teachers.

RICE, THURMAN B. *Living.* Chicago: Scott, Foresman and Company. 464 p.

Not a textbook but an excellent book for the high school library, and an unusually fine supplementary reference in biology and common learning courses. *Living* gives a very practical discussion of personal, mental, and environmental hygiene. It answers authoritatively many of the questions asked by boys and girls. The book is easy, interesting reading, interspersed with many practical illustrations. Dr. Rice is Professor of Medicine in the Indiana University Medical School and the author of numerous articles and publications.

SIMMONS, MAITLAND P. *The Young Scientist.* New York (386 Fourth Avenue): Exposition Press, 1951. 164 p. $3.00.

This is a series of science activities especially designed for general science classes but also of very great value and interest to teachers of elementary science. Here is a book that many science teachers are ever seeking—a source of interesting and challenging experiments and demonstrations for their classroom teaching. The book is especially timely as some similar books have been out of print for some time. The activities have been selected for their visibility to class, the sustaining of pupil interest, and their appropriateness in illustration of science principles. Usually each activity has a series of introductory and challenging questions, directions for study, observations to make, and questions requiring interpretations. Many of the experiments are illustrated with black and white drawings that add much to the clearness of the activities described. The materials to be used in the experiments are for the most part simple—found either at home, in the science laboratory, or in a ten-cent store.

There are eleven unit activities: air, the earth's crust, heat, composition of matter, forces of nature, water, foods, light, machines, sound, electricity, plant life, and animal life.

The author is a teacher of science in the Irvington High School, Irvington, New Jersey. He formerly taught general science in the junior high school at Everett, Massachusetts. He is a former general-science section chairman of the New Jersey Science Teachers Association. He is the author of a number of articles on science teaching and many readers will remember him as a past contributor to *Science Education.*

SMITH, VICTOR C., AND JONES, W. E. *Exploring Modern Science; Enjoying Modern Science; Using Modern Science.* Chicago: J. B. Lippincott Company, 1951. 353 p. 466 p. 654 p.

These are three books in the *Science for Modern Living* series being respectively for the seventh, eighth, and ninth grades. They are completely new books but based partly upon earlier books by Smith and Trafton. The three books form a complete junior high school series of general science texts.

The organization of each book is quite similar. There are six units. Each unit consists of one or two chapters. Each chapter is divided into a number of problems. Each problem is planned to serve as a day's program of work. Text, self-testing exercises, and suitable teacher or pupil demonstrations make up the problem. Each chapter has a summarizing review, word list for study, exercises in thinking, some things to explain, and some good books to read. There is a list of films with sources, suitable for the content of each chapter. The illustrations have been carefully selected and definitely planned as a learning activity.

The six units in *Exploring Modern Science* are: Air and Water; The World and the Universe; Good Health for Everybody; Fire and Heat; Our Earth's Weather; and Living Things and Man. There are 66 problems and 249 illustrations in this volume. The units in *Enjoying Modern Science* are: Uses of Energy; Community Health; Our Planet, the Earth; Consuming Wisely; The Atmosphere and Our Climate; and Living Things and Man. There are 84 problems and 319 illustrations in this volume. The Units in *Using Modern Science* are: Conserving Material Resources; Energy in Use; Living in Good Health; Living in a Modern World; Living in One World; and Conserving Living Resources. There are 123 problems and 464 illustrations in this volume.

The senior author Dr. Smith is head of the General Science Department in the Ramsey Junior High School, Minneapolis, Minnesota. Mr. Jones is chairman of the biology department, Evanston Township High School, Evanston, Illinois.

BLACKWOOD, OSWALD H., HERRON, WILMER B., AND KELLY, WILLIAM C. *High School Physics.* Boston: Ginn and Company, 1951. 672 p. $3.76.

High claims are made for *High School Physics.* The authors' state "it was written in response to their conviction that physics need not be an impossibly difficult subject for the high school student. It can be understood by a student if he is given a textbook written to be a guide and not merely compendium. This book is above all readable and understandable. It aims to evoke an active grasp of the material by the student, not simply a pouring-in of facts by teacher and textbook.—Unnecessary or overelaborate illustrations and examples of principles are not used. The more difficult theoretical materials are omitted."

There are forty-two chapters grouped under six units: Mechanics, Heat, Electricity, Wave Motion and Sound, Light, and Electronics and Nuclear Physics. Four appendices, a glossary, and index complete the book.

This book is different in several respects. More attention is given to electronic structure of matter and there are about thirty pages more or less on weather and atmosphere. There seems to be less textual descriptive material and many more problems than usually found in high school physics texts. Each chapter has a summary, list of technical words, questions for class discussion, problems and try it yourself exercises. The photographs and illustrations are unusually numerous and seemingly well selected. They should challenge the interest of most pupils and add much to the teaching effectiveness of the book. Sixteen of these large illustrations are in color.

There is teachers' manual to accompany the text.

Professor Blackwood is professor of Physics and Education at the University of Pittsburgh, Professor Kelly also teaches physics at the University of Pittsburgh, and Mr. Herron is head of the physics department in the Butler, Pennsylvania, High School.

SYMPOSIUM. *Applied Chemistry for High School Students.* Brooklyn, New York (110 Livingston Street): Board of Education of the City of New York, 1949, 79 p.

This course of study was developed by a representative committee of teachers and supervisors of the New York City high schools. Chairman of the committee was Samuel Schenberg of the Lafayette High School. *Applied Chemistry* has been taught in New York City schools for more than thirty years. The bulletin emphasizes the applied or practical aspects of a year course in chemistry. The first term's work is more theoretical and lays the basis for the more practical applications of the second term. It is suggested that teachers select two of the following three areas for the second term: (1) Fuels, Metals, and Alloys; (2) Textiles, Dyeing and Cleaning; (3) Drugs, Cosmetics, Insecticides, and Photography.

There is a suggested list of experiments and laboratory activities for each term and for each topic. A list of useful references are also included.

This would seem to be a very useful bulletin

for all chemistry teachers regardless of where they may be teaching.

SYMPOSIUM. *Safe Use of Electrical Equipment.* Washington, D. C.: National Education Association, 1951. 35 p. $0.50.

This pamphlet was prepared by the National Commission on Safety Education and the National Science Teachers Association. Chairman of the Committee was Professor George W. Haupt of the State Teachers College, Glassboro, New Jersey.

The bulletin is intended to help high school science teachers instruct students in the safe and proper use of electrical equipment commonly found in and around the home. Contents include: hazards, safeguards, miscellaneous domestic appliances, and teaching aids.

SYMPOSIUM. *Learning About Atomic Energy.* Salem, Oregon: Superintendent of Public Instruction, 1950, 31 p.

This is a guide for teaching atomic energy with units for ninth grade general science and senior social studies. The units were prepared by a committee of Oregon State teachers. Units for each of the two groups are included. The general science unit is more concerned with the science aspects of atomic energy. Each unit has stated objectives, study and discussion problems, and a list of selected references.

The bulletin should prove quite useful for science and social studies teachers concerned with teaching something about atomic energy.

SYMPOSIUM. *Science for the Oregon Schools. Part II. High School Science.* Salem, Oregon: Superintendent of Public Instruction, 1949. 181 p.

This science manual covers the science work for grades nine through twelve. The manual is designed to aid the science teacher in making science instruction more effective. It gives an overview of the science curriculum, the underlying philosophy, gives the content in terms of concepts, suggests essential experiences and provides many teaching aids such as supplementary reading, visual aids, suggestions on evaluation, and motivation.

Content areas are general science, biology, chemistry, physics, and physical science. Each area is divided into a number of teaching units and has objectives, a bibliography, teacher references, list of films, and so on.

The manual should prove a very valuable teaching aid when used intelligently. It seems to be quite well done. It is hoped that it won't make science teaching in Oregon schools too routinized or become a crutch for the lazy or poorly prepared teacher.

SYMPOSIUM. *The Iowa Plan for Atomic Energy.* Des Moines, Iowa: Department of Public Instruction, 1950. 15 p.

The state of Iowa seems to be one of a small number of states that is doing anything officially (insofar as state departments of education are concerned) about the problems of atomic energy. A great deal of teaching material published by individuals is available.

This bulletin gives consideration to: Basic Assumptions in Thinking and Planning in an Atomic Age, Historical Development of Atomic Science, Salient Scientific Facts About Atomic Energy, Social Aspects of Atomic Energy: Problems to Think About, Some Educational Implications, What Is the Iowa Elementary School Program in Atomic Energy?, What Is the Iowa Secondary School Program in Atomic Energy?, What Is the Iowa College Program in Atomic Energy?, and What Is the Iowa Adult Education Program in Atomic Energy?

SYMPOSIUM. *The Atom and You.* Des Moines, Iowa: Department of Public Instruction, 1950, 52 p.

This is a unit for secondary schools. It seems to be an excellent unit. The unit is planned for fifteen teaching days, with definite teacher lesson plans and student assignments for each day. There is a list of general objectives, keyed references and kits of materials, supplementary and follow-up activities, suggested audio-visual aids, evaluation and test suggestions, and a list of recommended books, pamphlets, documents, and magazines.

It is hoped that science teachers in Iowa high schools are using this excellent unit. It is unfortunate that most states do not have available such teaching units and that as a group science teachers are almost seemingly unaware of their responsibility and of the excellent teaching material that is available.

DAVIS, CHARLES E. *Senior Days at Davenport High.* New York: Julian Messner, Inc., 1951. 175 p. $2.50.

High school youth will enjoy this story about high school life—football, basketball, track, the school paper. Don Hamilton, football, basketball and track star, drives a car in which another football star, Howard Dean, is seriously injured. Suffering from concussion and amnesia Don goes to summon aid but forgets. As a result his companion and the student body, including his girl friend, Sally Dean, thinks he was merely a coward and ran away. Except for his friend, Jack Harper, colored football and track star, the whole student body, ostracizes him. And no condemnation can surpass that of youth by youth. The circumstantial evidence pointing to Don's guilt is very great but in the end Don gets the proof he needs and once more is accepted by the student body.

METCALFE, JUNE. *Aluminum from Mine to Sky.* New York: Whittlesey House, McGraw-Hill Book Company, 1947. 128 p.

In simple, non-technical language, Miss Metcalfe tells the life story of aluminum—an extraordinary metal with multiple purposes. She traces its evolution through history, mining and fabrication to its present form in thousands of items in everyday use. Altogether aluminum is one of the world's most fascinating and strategic metals. One wonders how a modern war could be fought at all without the use of aluminum.

This is an excellent supplementary book for the high school chemistry pupil and teacher. Few more worthwhile books could be added to the chemistry shelf of the school library. Numerous photographs add much to the reading interest. The author writes in a literary style easily read and understood, as well as enjoyed by the high school youngster.

SCIENCE CLUBS OF AMERICA. *Sponsor Handbook.* Washington, D. C. (1719 N Street, N. W.): Science Service, 1951. 116 p. $1.00.

Science teachers and science club sponsors always welcome each new edition of this valuable and extensively distributed handbook. It is almost a *must* for science club sponsors and about the best professional "buy" for the classroom teacher. It contains so much usable material for the classroom teacher. Contents include: How to Organize Your Science Club, Activities for Your Club, Projects Your Science Club Can Undertake, Co-projects for Your Club, How to Get Publicity, Affiliated Groups in Various States, Science Service Aids for Science Clubs, How to Conduct Your Science Fair, Tenth Science Talent Search, Recommended Books for Science Clubs, Free and Low Cost Materials for Science Clubs, and Where Science Clubs Are Located.

WAHL, ARTHUR C., AND BONNER, NORMAN A. *Radioactivity Applied to Chemistry.* New York: John Wiley and Sons, Inc., 1951. 604 p. $7.50.

Radioactivity Applied to Chemistry is designed to acquaint the reader with the possibilities of applying radioactivity to various fields of chemistry and to supply him with a comprehensive summary of the work that has been done. Part I consisting of ten chapters covers the principles and ideas involved in the application of radioactivity to chemistry. Part II, made up of nearly 200 pages of tables, covers factual information needed to apply the principles.

The authors are professors of chemistry at Washington University in St. Louis. Each worked as a radiochemist for the Manhattan Project.

DUSHMAN, SAUL. *Fundamentals of Atomic Physics.* New York: McGraw-Hill Book Company, 1951. 294 p. $5.50.

Fundamentals of Atomic Physics gives a thorough treatment of the kinetic theory of gases, the charge and mass of the electron, electronics, photoelectric effects, x-rays, the Bohr theory of the origin of spectral lines, electron configuration in atoms, matter waves, and isotopes. The book is designed for engineers and other technical men who need or desire to have a practical knowledge of atomic and nuclear fundamentals. An elementary knowledge of calculus is necessary.

OTTO, JAMES H., AND BLANC, SAM S. *Biology Investigations.* New York: Henry Holt and Company, 1951. 237 p.

This is a revision of the 1949 edition which was reviewed in the February, 1951, *Science Education.* It is a combination of a workbook and laboratory manual. This edition has increased both the number of basic investigations (to 85) and the number of special laboratory investigations (to 27). The workbook may be used with any textbook. In quality this workbook compares most favorably with similar manuals in biology. Mr. Otto is head of the science department of the George Washington High School, Indianapolis, Indiana. Dr. Blanc is a biology teacher in the East High School, Denver, Colorado.

BENDICK, JEANNE. *Electronics for Young People.* New York: Whittlesey House, McGraw-Hill Book Company, 1947. 175 p. $2.50.

Electronics for Young People is an introduction to electronics—what the science is, what electronics are, and how they are harnessed. Atomic theory and nuclear power, the giant offsprings of electronics are considered.

The many everyday uses of electronics are described: radio, fluorescent lights, thyratron, pliotron, burglar alarm, counting devices, radar diathermy, electron microscope, strobotron, movies, television, and so on. There are numerous black and white illustrations. Junior and senior high school pupils will enjoy this book. It is an excellent book for elementary, junior, and senior-high school teachers, and for the science library.

WATT, GEORGE W. *Laboratory Experiments in General Chemistry.* New York: McGraw-Hill Book Company, 1951. 227 p. $2.75.

This is the second edition of a college laboratory manual to accompany the text *General Chemistry* by Felsing and Watt.

NOLLER, CARL R. *Textbook of Organic Chemistry.* Philadelphia: W. B. Saunders Company, 1951. 643 p. $5.75.

Mindful of the usefulness of the earlier theories of gross structure concerning organic compounds,

the author integrates the newer theory of electronic structure in his treatment of organic reactions. He believes, also, that the student's criticism that too much memory work is involved in studying organic chemistry is often justified. He says that although "memory is necessary for all operations of reason" it is also true that theories which correlate facts are an aid to memory. This he has attempted to do in this book. Seemingly he has done an excellent job in this new approach to the study of organic chemistry.

Cable, Emmett James; Getchell, Robert Ward; Kadesch, Wlliam Henry; and Crull, Harry E. *The Physical Sciences.* New York: Prentice-Hall, Inc., 1951. 496 p. $5.50.

This is the third edition of a college textbook first published in 1940. Many changes have been made in the revised edition: new content, revised content, and many new illustrations. The section on astronomy has been completely rewritten. There are thirty pages of questions at the back and six pages of references.

For those teachers of physical science survey courses desiring a basic text this seems to be an excellent book—well written, well illustrated, well-selected content.

Horkheimer, Patricia A., and Diffor, John W. *Educators' Guide to Free Slidefilms.* Randolph, Wisconsin: Educators' Progress Service, 1951. 151 p. $3.00.

This is the third edition of the only complete guide to free slidefilms. It lists 504 titles of slidefilms, 76 more than were listed in any previous edition. In 1946, only 82 free slidefilms were available. This great growth in the last five years is indicative of an important educational trend. New titles (152 in all) are starred. Slidefilms are listed alphabetically by title, by title index indicating page of description, and by subject index. Source and availability index are listed by companies.

Directions are given for obtaining slidefilms. There is also a very important page on how to use slidefilms and your slidefilm guide.

Science teachers will find many useful slidefilms listed. Information regarding so many slidefilms is not available in any other single source.

Malvern, Gladys. *Behold Your Queen.* New York: Longmans, Green and Company, 1951. 218 p. $2.50.

This is the story of Queen Esther, wife of King Ahasuerus of ancient Persia. It is based on the Biblical account. In the fabulous palace at Shushan midst the intrigues of Haman, the Amalekite, and hater and would-be destroyer of the Hebrews, Queen Esther (formerly Hadassah) saves her people. Her wise Uncle Mordecai, responsible for her rearing, becomes chief adviser to King Ahasuerus. Altogether this is a story of high courage and daring.

Syme, Ronald. *Bay of the North.* New York: William Morrow and Company, 1950. 192 p. $2.50.

This is an interesting story of Pierre Radison who came to Canada from France in 1651. Later he was captured by the Iroquois, was adopted into the tribe, but finally escaped. By canoe and portage he went to Lake Huron, Lake Michigan and all of the way to the Mississippi. Still in his twenties, he became the first white man to discover the southern shore of Hudson Bay (Indian Bay of the North). He became a fur trader with the Indians but misfortune and false French friends kept him from the fortune he so richly deserved.

Finney, Gertrude E. *Sleeping Mines.* New York: Longmans, Green and Company, 1951. 241 p. $2.50.

This is the story of mining in western Montana. Susan Claremore determines to do the assessment work that is necessary to retain title to her late father's mining property—the government moratorium having come to an end. Her sister Isabel and mother Margaret with a young mining engineer Darris Fleetwood systematically search for the rich vein of silver ore found by the father. After many disappointments, much hard work, and danger from men secretly mining the vein, Susan finally succeeds. It is an interesting story of prospecting and mining that youngsters should thoroughly enjoy.

Murrill, William Alphonso. *Success Stories for Girls.* Gainesville, Florida (University of Florida): William A. Murrill, 1950. 63 p. $1.00.

There are twenty-seven stories entirely original and purely fictitious. Many of them have a science basis. The author is a wellknown scientist. He has many publications in the science field such as Stars, Rocks, Reptiles, Trees, Florida Plants, Florida Animals, Flowers, Familiar Trees, Ferns, and so on.

Herzberg, Max. *A Treasure Chest of Sports Stories.* New York: Julian Messner, Inc., 1951. 231 p. $2.75.

This is a compilation of sport stories previously published in other publications. Basketball, baseball, football, wrestling, hockey, track, racing, fencing, and skiing are covered. A number of the stories are by America's best known sports writers. Sport fans will find the stories exciting and full of human interest.

Decker, Duane. *The Catcher from Double-A.* New York: William Morrow and Company, 1950. 188 p. $2.50.

This is a story high school boys having a sports interest will thoroughly enjoy. It concerns Pete Gibbs and his friend Tweets Tillman who had more confidence in him than Pete had in

himself. Up with the champion Blue Sox for his third trial, it was now or never. Pete finally learns that confidence in himself is the first prerequisite for success.

HENMAN, WILLIAM. *Fighting Five.* New York: William Morrow & Company, 1950. 189 p. $2.50.

Boys especially will be interested in this story of basketball. The story concerns Jay Blaisdell, transfer to small Coville College from the State University. With the aid of Ben Collins, colored star and the able coaching of Matty Grogan they win the national college basketball championship from West Coast University and in doing so help break up a big basketball gambling syndicate.

HARLOW, ALVIN F. *The Ringlings: Wizards of the Circus.* New York: Julian Messner, Inc., 1951. 181 p. $2.75.

The Big Top is probably the one form of entertainment enjoyed equally by all—young and old, poor and rich. Whenever circuses are mentioned the names Ringling Brothers and Barnum and Bailey are remembered, especially by the millions who have seen either or both shows, and in later years the combined shows of both. This is the story of the Ringling Brothers—the trademark of the biggest and best of the circuses.

The seven Ringling Brothers, Al, Alf T., Gus, Charles, Otto, John, and Henry, together with their sister Ida (North) founded and actively directed the Ringling Circus, at one time all being associated in its operation until death separated them one by one. It all began with Al who had the "Circus in his blood." Al launched the show from their home in Baraboo, Wisconsin, in 1880. Baraboo long remained the winter headquarters of the circus. The book is replete with the successes and failures, the ups and downs of the Ringling Brothers. It is a most enjoyable story of *The Big Top.*

KUGELMASS, J. ALVIN. *Louis Braille.* New York: Julian Messner, Inc., 1951. 160 p. $2.75.

Peculiarly enough, this is the first complete biography of Louis Braille, the tragic genius who invented the system of reading and writing used by the blind. The author found authentic information almost inaccessible and his quest for materials took him to major and obscure libraries in almost every capital in Europe. Very sparse indeed are the published mentions of Braille's life. The great libraries in the United States have little. The Division of the Blind, Library of Congress, has nothing.

Louis Braille, who brought windows to the blind, was born in 1809, in the village of Coupuray, France. His father was a saddle maker. At the age of three, young Louis Braille accidentally lost the sight of both eyes.

Young Louis attended a school for the blind in nearby Paris taught by the understanding Hauy. His devoted father and mother and his friend Huay died when Louis was fourteen years old. Braille became a great organist and violoncellist. Because of a modest fortune left him by his parents, Braille lived relatively comfortably compared to the lot of most of the blind of his day. After much thinking he developed the Braille system of writing and reading universally used everywhere today. But in his lifetime Braille received only scorn and ridicule, leaving him cynical, embittered, and frustrated. Once again the world had refused to recognize a genius in its midst. Braille died in 1852 at the age of 43 of tuberculosis—unhonored, unwept, and unsung.

CRAIG, MARGARET MAZE. *Trish.* New York: Thomas Y. Crowell Company, 1951. 242 p. $2.50.

Trish is the story of seventeen year old Patricia Ingram, a high school senior who meets many of the problems and vexations of high school youth. How she meets many of these problems should hold the interest of many teen age girls and boys. Although fictional the book would be a fine supplementary book for the "common learnings" courses found in many high schools.

Recognizing the far reaching consequences science has for human society, these stimulating texts organize basic subject matter around problem areas having significance for young people in their everyday living.

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